



AQUATIC RESOURCES PROGRAM



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APPENDIX A

*Watershed Study for the South Sacramento
Habitat Conservation Plan and
Aquatic Resources Program*

DRAFT

**Watershed Study for the South Sacramento Habitat
Conservation Plan and Aquatic Resources Program**

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Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
amsl	above mean sea level
ARP	Aquatic Resources Program
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CNDDDB	California Natural Diversity Database
CNPS	California Native Plant Society
EPA	U.S. Environmental Protection Agency
HUC	Hydrologic Unit Code
MCRA	Mather Core Recovery Area
NHD	National Hydrography Dataset
NRCS	National Resources Conservation Service
SSHCP	South Sacramento Habitat Conservation Plan
SSURGO	Soil Survey Geographic
TAC	Technical Advisory Committee
UDA	Urban Development Area
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USB	Urban Services Boundary
USGS	U.S. Geological Survey

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1 INTRODUCTION

1.1 Purpose of the Watershed Study

The purpose of the watershed study for the South Sacramento Habitat Conservation Plan (SSHCP) and Aquatic Resources Program (ARP) is to describe the overall characteristics of watersheds in the SSHCP and ARP area (collectively called “Plan Area” in this document) (Figure 1). The framework of the watershed study is to describe the physical locations of the watersheds, including what proportion of each watershed is within the Plan Area, as well as the overall conditions of the watersheds in terms of environmental setting (e.g., land formations, soils, topography, existing land use), hydrology, and biological resources. In addition, the watershed study describes how the SSHCP Preserve System relates to each watershed located within the Plan Area, as one of the primary purposes of the SSHCP and ARP is to protect watershed functions, as described below:

Protect Watersheds: Watershed function, and specifically hydrologic regimes, is an important determinant of certain aquatic resource-dependent and aquatic resource-associated plants and wildlife. Therefore, preserving upland landscapes associated with wetland features for maintaining aquatic resource-dependent and wetland-associated species is of primary importance. Sufficient sub-watershed area should be preserved so that natural sources of surface and sub-surface water influx and outflow remain intact, and potential development-related increases in surface runoff and sources of water pollution are avoided (e.g., runoff from roads, roofs, paved surfaces, utility pipes, landscaped areas).

1.2 Definition of Watershed

A watershed is defined by the U.S. Environmental Protection Agency (EPA) as a “land area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately the oceans” (33 CFR 332.2). The U.S. Department of Agriculture (USDA) further defines a watershed as “a geographic area of land, water and biota within the confines of a drainage divide” (USDA 2007). According to the USDA, “watershed boundaries define the aerial extent of surface water drainage to a point. Watershed boundaries always follow the highest ridgeline around the stream channels and meet at the bottom or lowest point of the land where water flows out of the watershed. The boundary between watersheds is defined as the topographic dividing line from which water flows in two different directions” (USDA 2007).

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1.3 Functions and Services of Watersheds

According to Black (1997), there are five clearly identifiable functions of watersheds, three that are hydrologic (collection, storage, and discharge) and two that are ecological (chemical and habitat). The hydrologic functions of watersheds include the (1) **collection** of water from rainfall snowmelt and storage that becomes runoff, (2) **storage** of water of various amounts and durations, and (3) **discharge** of water as runoff. The ecological functions of watersheds include (4) providing diverse sites and pathways along which vital **chemical** reactions take place, and (5) providing **habitat** for the flora and fauna that constitute the biological elements of an ecosystem (Black 1997).

There are numerous anthropogenic and biological values of watersheds. According to Postel and Thompson (2005), healthy watersheds provide the following: water supplies for agricultural, industrial, and urban-domestic uses; water filtration/purification; flow regulation; flood, erosion, and sedimentation control; fisheries; timber and other forest products; recreation/tourism; biodiversity preservation; aesthetic enjoyment; climate stabilization; and cultural, religious, and inspiration values.

1.4 Anthropogenic Impacts to Watersheds

Modification of natural landscapes (i.e., vegetation, topography, and hydrology) is one of the prime human impacts on watersheds. Altering natural landscapes for development purposes, resource extraction, or recreation can affect collection, storage, and discharge functions of a watershed. Changes in the landscape resulting from these human activities can increase sedimentation and erosion, increase or redirect natural runoff, and alter hydrologic regimes, including timing of flows and groundwater recharge. In addition, land use modification or conversion can change the way a watershed is used by individual species or species communities, including their distribution and abundance within a watershed (i.e., habitat function) and can directly or indirectly affect the chemical reactions required for the watershed to sustain itself.

Introduction of pollutants into the watershed can happen directly through agricultural activities and runoff from impervious surfaces in more urbanized areas. Over the years, an increase of impervious surfaces has caused “significant changes to both the quality and quantity of the stormwater runoff, leading to degraded stream and watershed systems: an increased quantity of stormwater for stream process to absorb sedimentation, and an increased pollutant load carried by the stormwater” (Morisawa and LaLure 1979, Arnold et al. 1982, Bannerman et al. 1993, as cited in Brabec et al. 2002).

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2 METHODS

2.1 Assembly of Baseline Data

Watersheds within the Plan Area were identified by overlaying the Plan Area with the U.S. Geological Survey (USGS) hydrologic unit map data. The watersheds were then intersected with land cover, hydrologic, geological, soil, slope, and elevation data that were assembled for the SSHCP to describe their physical and biological settings. The watersheds were also intersected with known occurrences of plant and animals species that are proposed for regulatory coverage under the SSHCP (Covered Species) and the proposed SSHCP Preserve System. Descriptions of the datasets used in the SSHCP and this watershed study are provided in the following subsections.

2.1.1 USGS National Hydrography Dataset

Watersheds in the United States are delineated by the USGS using a hierarchical system, which divides the U.S. into 21 regions, 221 subregions, 378 hydrologic accounting units, and 2,264 cataloging units (USGS 2013). Each hydrologic unit is identified by a unique Hydrologic Unit Code (HUC) consisting of two to eight digits based on the levels of classification in the hydrologic unit system (USGS 2009). Two additional levels were recently added to the hydrologic unit hierarchy: watershed (10-digit) and subwatershed (12-digit).

For the purpose of this watershed study, the Plan Area was divided at the 10-digit HUC level (i.e., watershed), which yields 10 watersheds within the Plan Area (Figure 2). Note that an 11th watershed, Cache Slough, appears on Figure 2; however, that watershed makes up only 6 acres of the Plan Area and therefore is not analyzed in this study.

2.1.2 Land Cover Dataset

Land cover mapping for the Plan Area occurred in several stages. Vernal Pool and Swale land cover type mapping occurred early in the SSHCP planning process and was accomplished through interpretation of black-and-white aerial imagery dated March 2001 and mapped at a scale of 1 inch = 200 feet (1:2,400). The primary mapping of all other land cover types was completed in 2004 and was developed from the interpretation of color aerial imagery dated November 2002 and mapped at a scale of 1 inch = 400 feet (1:4,800). These original mapping efforts have been updated and refined at various times to reflect modifications of land cover types, such as cover type conversion, to accommodate an expansion of the Plan Area boundary and to correct errors in the original mapping. The current land cover map provides fairly detailed information for the existing conditions in the Plan Area based on 2009 aerial photos and limited field-truthing, with the updates occurring in May 2010, September 2012, January 2013, March 2013, November 2013, May 2014, June 2014, August 2014, and December 2014.

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The land cover classification system developed for the SSHCP is a modification of the California Department of Fish and Game (CDFG)¹ List of California Natural Communities. There are 25 land cover types in the Plan Area, of which 17 provide native (e.g., Blue Oak Woodland) or naturalized (e.g., Valley Grasslands, Agriculture) conditions that have habitat value for Covered Species (Figure 3). The other eight land cover types, including developed and disturbed types, have little or no habitat value for Covered Species.

The land cover data were also used to generate a relative measure of impervious surfaces in the Plan Area. Impervious surfaces (e.g., paved roads, parking lots, driveways, rooftops, sidewalks) reflect urban intensity and may be used as a metric for adverse impacts to natural resources as a result of increased runoff, sedimentation, and pollutant loads into receiving waters (Brabec et al. 2002). For the purposes of this study, impervious surfaces are defined as Aqueduct, High-Density Development, and Major Roads. The Aqueduct land cover type is represented by the Folsom South Canal. The High-Density Development land cover type includes urban and suburban residential neighborhoods, urban centers, industrial areas, airports, and wastewater treatment plants. Most of this high-density development occurs inside the Urban Development Area (UDA) in the northwestern portion of the Plan Area. The Major Roads land cover type includes linear features with paved surfaces and can vary from large freeways to smaller arterial roads found within urban settings. It should be noted that this relative measure of impervious surfaces is not intended to calculate actual impacts, such as amount of runoff, etc., but rather to generally characterize the existing urban intensity in the Plan Area and to compare and contrast the different watersheds.

Low-density development was not included in the Impervious land cover category. While this land cover includes some impervious surfaces (e.g., driveways), it primarily consists of relatively sparse residences and other structures, such as farm buildings and small rural neighborhoods with large individual property sizes per house. Plant nurseries are also included in this category.

2.1.3 Hydrology

The USGS (2013) National Hydrography Dataset (NHD) contains hydrologic features such as lakes, ponds, streams, rivers, canals, dams, and stream gages (USGS 2013). The NHD dataset was intersected with the Plan Area to determine the type and quantity of hydrologic features within each watershed (Figure 4).

¹ The List of California Natural Communities was published by the CDFG before CDFG was formally renamed California Department of Wildlife (CDFW) in January 2013. Information from the CDFG prior to January 2013 therefore will be attributed to CDFG in this document, although the names are synonymous.

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2.1.4 Geological Formations

The geological formations were derived from the Generalized Geological Map of Sacramento County prepared by the California State Geological Survey (CDMG 1999) (Figure 5). The Generalized Geological Map of Sacramento County, also referred to as a time-stratigraphic correlation map, is based on a correlation of similar-aged rock units from the east side of the Sacramento Valley with those on the west side of the valley, as well as a correlation of rock units from the northern Sacramento Valley with similarly aged rock units in the southern San Joaquin Valley. Because the time-stratigraphic correlation map is prepared on a small scale in the Plan Area, it provides excellent detail and well-refined demarcations in geologic units. However, geological formation data are unavailable for portions of four watersheds located in the western portion of the Plan Area; areas lacking data are identified in the descriptions of the four relevant watersheds in Section 3.2.

2.1.5 Soils

Individual soil units are organized into map units called soil associations, which consist of soil units of the same texture and composition that occur in geographic position. Soils for the Plan Area are from the National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (USGS and USDA NRCS 2009) (Figure 6).

2.1.6 Slope and Elevation

Both slope and elevation for the Plan Area were derived from the USGS National Elevation Dataset (USGS 2012) (Figures 7 and 8).

2.1.7 SSHCP Covered Species

A Technical Advisory Committee (TAC), with the assistance of outside experts, created a list of 28 plant and wildlife species proposed for federal regulatory coverage under the SSHCP. The TAC compiled data from a variety of sources, including the CDFG, California Natural Diversity Database (CNDDDB), U.S. Fish and Wildlife Service (USFWS) files and databases, California Native Plant Society (CNPS) plant inventories, Sacramento County Audubon files, and solicited opinions from local experts and university researchers and staff from resource agencies. Occurrence data for Covered Species were generated from the data compilation effort and are described in detail in the SSHCP.

For the purposes of the direct effects and conservation analyses, Covered Species habitat was modeled based on the associations between species occurrence data and particular land cover types in the Plan Area and through review by species experts. This information was compiled to

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generate models for land cover types and ranges within the Plan Area that each Covered Species is likely to use for breeding, foraging, and/or cover, or other important life history activities. Chapter 3 of the SSHCP describes the methods and results of those models. Figures 9-1 through 9-5 depict Critical Habitat for Sacramento Orcutt grass, slender Orcutt grass, vernal pool fairy shrimp, vernal pool tadpole shrimp, and California tiger salamander. Figures 9-6 through 9-29 depict modeled habitat and species occurrences for the 28 Covered Species.

2.1.8 Preserve Design

This section briefly describes the SSHCP Conservation Strategy in terms of identifying the primary development areas, geographically based Preserve Planning Units, existing conservation (e.g., existing biological Preserves, mitigation sites), and planned conservation that would occur through implementation of the SSHCP. A detailed description of the SSHCP Conservation Strategy is contained in Chapter 7 of the SSHCP.

Urban Development Area/Outside Urban Development Area

The UDA is where the large majority of SSHCP Covered Activities will occur, including anticipated residential, commercial, and industrial development and associated infrastructure (e.g., roads, utilities). For the purpose of the SSHCP and watershed study, it is assumed that the UDA will eventually be built out except for the existing and proposed preserves. Outside the UDA, SSHCP Covered Activities will primarily be limited to infrastructure projects. These include transportation projects, including road upgrade projects, road realignment/extension projects, interchange projects, and connector projects. Covered activities outside the UDA would also include water-related utility projects, including recycled water projects and operations and maintenance of flood control and storm drainage infrastructure.

Preserve Planning Units

To assist with development of an adequate SSHCP Conservation Strategy, the Plan Area was further divided into eight Preserve Planning Units (PPUs) that encompass areas where important Covered Species resources are present, and where habitat preservation will be planned (see Figure 1-1 in the SSHCP). These eight SSHCP PPUs are geographic subdivisions of the Plan Area designed to ensure that adequate Biological Goals and Measurable Objectives (Table 7-1 in the SSHCP) were developed for all biological resources located within the Plan Area.

PPUs were delineated to capture specific habitat or agricultural land cover types or areas identified as being important for a specific suite of species. For instance, PPU 7, which is located in the southeastern portion of the Plan Area, was delineated to encompass the vast majority of

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vernal pool grasslands remaining in the County. PPU 7 also contains the designated Cosumnes/Rancho Seco Core Recovery Area (USFWS 2005), which is considered an important area for protection of vernal pool species. PPU 2 contains the designated Mather Core Recovery Area (USFWS 2005). PPU 6, located in the southwestern portion of the Plan Area, was delineated to encompass a vast majority of agricultural cover types that provide foraging habitat for many covered raptor species. While geopolitical or physical landmarks were used to delineate some PPU boundaries, this was done for ease of mapping and to make locating PPU boundaries in the field easier.

Existing Preserve Lands

The Plan Area supports several established Preserves both inside and outside of the UDA. Existing Preserve totals approximately 64,536 acres (17%) in the Plan Area and includes wildlife refuges, nature preserves, lands under conservation easements, open space, mitigation banks, and individual project mitigation sites. Of the 61,364 acres of existing Preserve, 3,172 acres (5%) are inside the UDA and 61,360 acres (95%) are outside the UDA. Existing Preserve areas are considered in the SSHCP to be protected for their resource values, and although they do not count as mitigation for future Covered Activities, they were carefully considered in the SSHCP Conservation Strategy so that proposed preserves can augment and link to the existing Preserves.. Valley grassland comprises 35,290 acres (55%) of the existing Preserve lands, followed by agriculture at 12,365 acres (17%), and blue oak woodland and savanna at 7,223 acres (11%). Existing Preserve also supports substantial acreages of riparian woodland and riparian scrub (2,510 acres, 4%), vernal pool and swale (2,336 acres, 4%), freshwater marsh (1,057 acres, 3%), and open water (720 acres, 1%).

Planned Conservation

Planned conservation will include both planned “hardline” Preserve based on known projects and currently proposed mitigation, and “criteria-based” conservation for future projects. The boundaries of the new criteria-based Preserves are not known at the time of SSHCP preparation.

The planned hardline Preserves in the Plan Area total 1,717 acres. Including the planned hardline Preserves, it is anticipated that approximately 37,030 acres will be newly conserved in the SSHCP Preserve System. The new criteria-based Preserves will be established according to the Conservation Actions for each of the relevant Biological Goals and Measureable Objectives included in Chapter 7 of the SSHCP (see Table 7-1 of the SSHCP).

The Laguna Creek Wildlife Corridor is identified separately from the other Preserves because it is a distinctive and important landscape feature in the Plan Area and is important for maintaining regional

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movement and resident habitat for wildlife, conserving riparian habitat, and maintaining hydrologic connections between Preserves inside the UDA. The Laguna Creek Wildlife Corridor will be established through a combination of planned hardline and criteria-based preservation.

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3 RESULTS

3.1 Summary of Watersheds in Plan Area

The Plan Area includes a portion or the entirety of 10 watersheds (10-digit hydrologic units), as defined by the Federal Standard for Delineation of Hydrologic Unit Boundaries (USGS and USDA NRCS 2009). Those 10 watersheds are American River, Deer Creek, Laguna Creek, Lower Cosumnes River, Lower Dry Creek, Lower Mokelumne River, Morrison Creek, Sherman Lake-Sacramento River, Snodgrass Slough, and Upper Cosumnes River (Table 1, Figure 2). One additional watershed, Cache Slough, intersects the Plan Area but only comprises 6 acres in the Plan Area and therefore is not discussed in the watershed study.

The Laguna Creek and Morrison Creek watersheds account for about 37% of the Plan Area, and the next three largest watersheds (Deer Creek, Lower Cosumnes, and Snodgrass Slough) watersheds account for another 41%, resulting in the five largest watersheds making up 78% of the Plan Area.

Table 1
Summary of Watersheds in Plan Area

Watershed	Acres of the Watershed in Plan Area	Total Watershed Acreage	Percent of Watershed in Plan Area	Cumulative Percentage of Watershed in Plan Area
Laguna Creek	73,976	96,788	76.4%	23.3%
Morrison Creek	42,926	69,540	61.7%	13.5%
Snodgrass Slough	40,426	51,616	78.3%	12.7%
Lower Cosumnes River	46,682	46,683	100.0%	14.7%
Deer Creek	43,803	81,504	53.7%	13.8%
Upper Cosumnes River	31,885	114,793	27.8%	10%
Lower Dry Creek	18,493	56,110	33%	5.8%
Sherman Lake-Sacramento River	13,987	121,608	11.5%	4.4%
American River	3,452	65,103	5.3%	1%
Lower Mokelumne River	2,019	141,965	1.4%	1%
Grand Total¹	317,655	845,709	28.5%	100%

¹ The total does not include the approximately 268,589 acres of the Cache Slough watershed, which is not discussed in this document.

3.1.1 Land Cover Types in Plan Area

The Plan Area is organized into four main land cover types (Table 2, Figure 3):

Terrestrial. Natural terrestrial land covers comprise approximately 78% of the Plan Area, with valley grassland accounting for 43% of the terrestrial land cover. Blue oak woodland and

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savanna account for about 5% of the terrestrial land cover, and riparian communities account for about 3% of the terrestrial land covers.

Aquatic. Aquatic land covers comprise approximately 5% of the natural land covers in the Plan Area, with vernal pool accounting for 1% of the aquatic land covers, and remaining acreage distributed among the other types, including streams/creeks (VPIH) at less than 0.1%, freshwater marsh at 0.9%, open water at 1%, seasonal wetland at 1%, streams/creeks at 1% and swale at 0.4%.

Agriculture. Agriculture comprises about 31% of the Plan Area, with croplands accounting for about 16%, vineyards at 8%, irrigated pasture-grassland at 5%, and orchards at 1%.

Non-Habitat. Non-habitat land covers comprise about 14% of the Plan Area, with low- and high-density development and major roads accounting for about 11% of the non-habitat land covers.

Impervious surfaces (i.e., aqueduct, high-density development, and major roads) total approximately 16,101 acres, or 5% of the Plan Area. Most of the impervious surfaces are located inside the UDA in the northwestern portion of the Plan Area.

3.1.2 Hydrology in the Plan Area

Flowline data are important for the watershed analysis because they describe the flow directions and networks within a watershed. These data, for example, allow for analyses about the effects of upstream hydrologic alterations (e.g., flow rates, timing of peak flows) or discharge of pollutants on downstream hydrology, water quality, and important resources such as aquatic and riparian wildlife habitat.

The Plan Area consists of five NHD flowline features (Table 3, Figure 4).

Stream/River. A stream/river is a naturally flowing body of water that may be perennial, intermittent, or ephemeral (USGS and USDA NRCS 2009). Stream/river accounts for approximately 841 miles of flowline features in the Plan Area and about 60% of the total flowline features.

Canal/Ditch. A canal/ditch is an “artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft” (USGS 2009). Canal/ditch is also an important flowline feature in the Plan Area, totaling approximately 347 miles in the Plan Area and comprising about 25% of the flowline features.

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Table 2
Summary of Land Cover Types in Plan Area by Watershed

Land Cover Types	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)	Grand Total (acres)	Percent of Plan Area
<i>Terrestrial</i>												
Blue Oak Savanna	—	2,018	2,550	—	529	—	18	—	—	521	5,637	1.8%
Blue Oak Woodland	—	4,400	1,364	—	1,417	—	—	—	—	1,951	9,132	2.9%
Mine Tailing Riparian Woodland	48	41	158	17	—	—	129	2	—	245	641	0.2%
Mixed Riparian Scrub	—	80	61	285	47	2	200	130	548	100	1,454	0.5%
Mixed Riparian Woodland	0.4	836	262	1,929	401	196	157	51	1,293	733	5,856	1.8%
Valley Grassland	1,336	23,643	42,178	14,593	7,965	0.1	21,294	665	5,947	17,531	135,166	42.5%
<i>Terrestrial Total</i>	<i>1,384.4</i>	<i>31,018</i>	<i>46,573</i>	<i>16,824</i>	<i>10,359</i>	<i>198.1</i>	<i>21,798</i>	<i>848</i>	<i>7,788</i>	<i>21,081</i>	<i>157,886</i>	<i>50%</i>
<i>Aquatic</i>												
Streams/Creeks (VPIH)	—	19	—	—	—	—	55	—	—	—	73	<0.1%
Freshwater Marsh	2	38	167	1,127	47	21	370	40	1,030	112	2,954	0.9%
Open Water	3	200	297	663	9	3	159	9	720	280	2,344	0.7%
Seasonal Wetlands	23	129	419	616	117	—	107	—	782	409	2,600	0.8%
Streams/Creeks	6	228	416	345	78	67	123	24	1,141	350	2,778	0.9%
Swale	3	160	428	144	65	—	359	1	10	81	1,252	0.4%
Vernal Pool	7	274	1,917	619	203	0.1	764	5	421	325	4,535	1.4%
<i>Aquatic Total</i>	<i>98</i>	<i>1,048</i>	<i>3,644</i>	<i>3,514</i>	<i>519</i>	<i>91.1</i>	<i>1,937</i>	<i>79</i>	<i>4,104</i>	<i>1,557</i>	<i>16,536</i>	<i>5.2%</i>

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Table 2
Summary of Land Cover Types in Plan Area by Watershed

Land Cover Types	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)	Grand Total (acres)	Percent of Plan Area
<i>Agriculture</i>												
Cropland	—	4,065	5,958	12,614	2,742	1,671	2,245	4,986	16,275	1,273	51,829	16.3%
Irrigated Pasture-Grassland	—	836	5,070	3,447	316	8	1,399	0.1	3,295	1,620	15,991	5%
Orchards	—	137	612	116	212	—	199	1,749	653	229	3,907	1.2%
Vineyards	—	4,231	5,805	4,976	3,821	0.4	330	1,260	5,560	476	26,460	8.3%
<i>Agriculture Total</i>	—	9,269	17,445	21,153	7,091	1,679.4	4,173	7,995.1	25,783	3,598	98,187	31%
<i>Non-Habitat</i>												
Aqueducts	40	21	31	41	—	—	72	11	—	49	264	<0.1%
Disturbed	98	844	163	69	1	13	3,390	177	190	1,341	6,287	0.2%
High-Density Development	1,531	44	919	667	29	25	6,102	3,049	583	122	13,073	4.1%
Low-Density Development	7	864	4,284	3,976	421	6	3,703	403	1,433	3,510	18,608	5.6%
Major Roads	144	123	467	353	56	4	597	310	541	170	2,764	0.9%
Mine Tailings	18	127	306	—	—	—	212	13	—	422	1,098	3.4%
Recreation/Landscaped	185	444	143	85	17	—	943	323	6	36	2,180	6.9%
<i>Non-Habitat Total</i>	2,023	2,467	6,313	5,191	524	48	15,019	4,286	2,753	5,650	44,274	13.9%
Grand Total	3,452	43,803	73,976	46,682	18,493	2,019	42,926	13,987	40,426	31,885	317,649¹	—

¹ The total does not include the approximately 6 acres of the Cache Slough watershed, which is not discussed in this document. This total also does not include approximately 800 acres of unmapped lands along the Sacramento River, on the river side of the levees.

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Table 3
Summary of NHD Flowlines in Plan Area by Watershed

Watershed	Artificial Path		Canal/Ditch		Connector		Pipeline		Stream/River		Grand Total	
	<i>Feet</i>	<i>Percent</i>	<i>Feet</i>	<i>Percent</i>	<i>Feet</i>	<i>Percent</i>	<i>Feet</i>	<i>Percent</i>	<i>Feet</i>	<i>Percent</i>	<i>Feet</i>	<i>Percent</i>
American River	23,396	48.3	2,325	4.8	—	—	227	0.5	22,484	46.4	48,432	1
Deer Creek	52,425	5.6	68,836	7.4	7,995	0.9	1,207	0.1	799,852	86.0	930,315	12.6
Laguna Creek	125,769	6.6	141,811	7.5	154	<0.1	1,312	<0.1	1,630,736	85.8	1,899,782	25.8
Lower Cosumnes River	236,780	21.8	375,506	34.6	27	<0.1	73	<0.1	471,829	43.5	1,084,215	14.7
Lower Dry Creek	26,254	5.5	33,152	7.0	805	0.2	—	—	414,948	87.3	475,159	6.5
Lower Mokelumne River	11,195	12.0	81,978	88.0	—	—	—	—	—	—	93,173	1.3
Morrison Creek	72,483	10.5	40,079	5.8	4,048	1	2,912	0.4	573,510	82.8	693,032	9.4
Sherman Lake-Sacramento River	65,946	26.9	172,021	70.1	81	<0.1	323	0.1	6,858	2.8	245,230	3.3
Snodgrass Slough	243,185	20.8	846,039	72.2	4,195	0.4	—	—	77,909	6.7	1,171,326	15.9
Upper Cosumnes River	199,470	27.9	68,518	9.6	507	0.1	903	0.1	444,746	62.3	714,142	9.7
Grand Total	1,056,962	14.4	1,830,311	24.9	17,812	0.2	6,957	<0.1	4,442,871	60.4	7,354,913	100.0

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations. Any discrepancies in individual totals are due to rounding but the grand total for each watershed is consistent.

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Connector. A connector is “A known, but nonspecific, connection between two nonadjacent network segments,” such as a two-dimensional dam/weir that causes a gap between an upstream lake/pond and downstream stream/river (USGS 2009). Connectors make up about 3 miles in the Plan Area, but only 0.2% of the flowline features.

Pipeline. A pipeline is “A closed conduit, with pumps, valves and control devices, for conveying fluids, gases, or finely divided solids” (USGS 2009). About one mile of pipeline is included in the NHD dataset, accounting for less than 0.1% of the flowline features in the Plan Area.

Artificial Path. An artificial path is used as a surrogate to complete flowlines between NHD waterbodies and NHD areas where there is no obvious channel (USGS 2009). It is the connection between the inflow and outflow points of an in-line open water body. Artificial paths are restricted to one or more of the following features that may occur in the Plan Area:

- Lake/pond;
- Stream/river;
- Swamp/marsh;
- Canal/ditch;
- Wash; or
- Area of complex channels.

About 200 miles of artificial path are included in the NHD dataset, accounting for about 14% of the flowline features in the Plan Area.

3.1.3 Geological Formations in Plan Area

A geologic formation is a geomorphic feature on the Earth’s surface representative of an episode of landscape development. The Plan Area includes 17 geological landforms (Table 4, Figure 5). Approximately 57% of the Plan Area is underlain by two main landforms types: Laguna Formation (19%) and the Riverbank Formations (38%).

Riverbank Formations (Qr)

The riverbank formations included four mapping units: Riverbank Formation, Undivided; Riverbank Formation, Upper Unit; Riverbank Formation, Middle Unit; and Riverbank Formation, Lower Unit.

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The Riverbank Formation, Undivided, occupies the central portion of the Plan Area, generally subdivided by the Cosumnes River and Deer Creek. In the vicinity of Elk Grove, the Riverbank Formation is about 10 miles wide from west to east. To the east, it laps onto older materials composed of the Laguna Formation and the Turlock Lake Formation. To the west, it is overlain by younger alluvial materials. The Riverbank Formation, Undivided, as well as the other Riverbank formations, were deposited on a plain of aggradation that has been partly dissected. The upper surface of this plain, in most places, represents the upper surface of the Riverbank Formation. The upper surface is characterized by a gently undulating surface. Local variations in relief may be as much as 15 feet. The age of the Riverbank Formation ranges from middle to late Pleistocene and is probably related to the Donner Lake advance of Sierran glaciation. The Riverbank Formation consists of interbedded granitic sand, silt, and clay with metamorphic channel gravels. Its sediments are very similar to those in the Laguna Formation.

The Riverbank Formation, Upper Unit, is located in the southwestern portion of the Plan Area and borders Laguna Creek in the eastern portion. It is unconsolidated, compact dark brown to red alluvium.

The Riverbank Formation, Middle Unit, includes a small area along the north-central boundary of the Plan Area and a larger area along the south-central boundary. The Middle Unit, Riverbank Formation, is locally and remotely derived granitic and basic igneous alluvium (sand, silt, clay, and gravel).

The Lower Unit, Riverbank Formation, is located in the northwestern portion of the Plan Area and consists of red semi-consolidated gravel, sand, and silt. Its surface is higher and much more dissected than the Upper Unit and has much stronger soil profiles.

Copper Hill Volcanics (Jch)

The Copper Hill Volcanics comprise dark to medium green mafic to andesitic pyroclastic rocks deposited in the Late Jurassic (~163-145 million yrs). These volcanics are of similar age to the Salt Spring Slate (Clark 1964) and are found interfingering with the Salt Springs Slate in the northeast corner of the SSHCP area, at elevations above 400 feet above mean sea level (amsl).

Gopher Ridge Volcanics (Jgo)

The Gopher Ridge Volcanics are extrusive volcanic rocks ranging from fine tuff to coarse volcanic breccias and lavas (Clark 1964). The fine tuff is yellow green in color on a fresh face, but weathers to a dark gray, resembling the Salt Spring Slate. These volcanics have been extensively folded and faulted in the same metamorphic belt as the Salt Spring Slate and Copper

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Hill Volcanics. The Gopher Ridge Volcanics are the oldest deposits of this group and are found along the western edge of the metamorphic belt at elevations above 150 feet amsl.

Intertidal Deposits (Qi)

The Intertidal Deposits are primarily peat and peaty mud formed in tidal marshes and swamps along the Sacramento River (Atwater 1979). These deposits form in areas influenced by tidal fluctuations in the San Francisco Bay and Sacramento Delta, and are therefore found at elevations within a few feet of mean sea level. These Holocene (<10,000 years) deposits typically range in thickness from 3 to 9 feet, and are mapped in the southwestern portion of the SSHCP.

Mine and Dredge Tailing (t)

Deposits of tailings occur south of the American River near Nimbus and at other scattered localities in the central and eastern portions of the Plan Area. These tailings are the result of gold dredge operations and consist of windrows of gravel, cobbles, boulders, sand, and silt. The largest single expanse of tailings extends from near Folsom southwesterly nearly to Mather Field, a distance of about 12 miles; it has a width that ranges from 1 to 4 miles and covers an estimated 12,000 acres.

Chico Formation (Ku)

The Chico formation is comprised of fossiliferous marine sandstone and minor siltstone found in the eastern portion of the Plan Area.

Basin Deposits (Qhb)

During the Holocene epoch, Basin Deposits formed in sink areas and occur now as unconsolidated clay, silt, and other fine materials. This formation covers a total of 663 acres in the eastern-most corner of the SSHCP Plan Area.

On this formation, four vernal wetlands were mapped. They cover a total of 3.1 acres, all outside the UDA. Average size (mean $\pm$ SE) of vernal wetlands on Basin Deposits is 0.78 ± 0.228 acres. Each of the four wetlands on this formation is 0.10 acre or larger.

Two deep pools occur in the Basin Deposits Formation outside the UDA that total 2.4 acres.

Alluvium (Q)

Undifferentiated alluvial deposits are sand, silt, and clay sedimentary deposits found in active stream channels. These deposits are unconsolidated and are found at lower elevations than older alluvial terrace deposits. Within the SSHCP area, these deposits are found along an

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approximately 3-mile-long reach of a tributary to the Cosumnes River west of the Amador County Line and south of Jackson Road, and along an approximately 2-mile-long reach of a tributary to Dry Creek in the southeastern portion of the SSHCP area.

Levee and Channel Deposits (Qa)

Unconsolidated to poorly consolidated Levee and Channel Deposits are Holocene (<10,000 years) sediments that typically range in size from sand to clay size particles and are deposited during flood events when a river overtops its banks. These deposits are mapped along approximately 12 miles of the active stream channel of the Cosumnes River (Wagner et al. 1981). At their upstream extent, approximately 1 mile northeast of Wilton, the levee and channel deposits overlie the lower member of the Modesto Formation. The downstream extent of the levee and channel deposits occurs at the intersection of the Cosumnes River and Twin Cities Road.

Salt Springs Slate (Jss)

The Salt Spring Slate is a dark gray slate with poorly sorted angular grains of quartz and feldspar set in a fine grained clay matrix. Conglomerates associated with these deposits are fine grained with well-rounded pebbles (Clark, 1964). The Salt Spring Slate, found at elevations above 200 feet MSL in the eastern portion of the SSHCP area, is part of a northwest/ southeast trending volcanic and metamorphic belt that has been extensively folded and faulted.

Modesto-Riverbank Formation (Qmr)

The Modesto-Riverbank formation is a late Pleistocene (125,000 to 10,000 years) alluvial deposit comprising sand, silt, and gravel derived from the Sierra Nevada Mountains to the east. These fluvial terrace deposits are typically semi-consolidated and tend to form thin, impermeable soils, underlain by shallow hardpan. The formation is found along the Dry Creek, Laguna, and Browns Creek floodplains in the southeastern portion of the SSHCP area (Wagner et al. 1981).

North Merced Gravels (Qtnm)

The North Merced gravels are made up of well-rounded pebbles and cobbles of dark-colored metamorphic rocks. The formation occurs as a thin veneer, capping hills in the east-central part of Sacramento County. The southernmost outcrop area of the gravels is along the top of a southwesterly trending ridge about 2 miles north of Dry Creek. The gravels here overlie sediments of the Laguna Formation and rise from an elevation of about 150 feet to over 320 feet at their eastern extremity. Farther north, the gravels cap other flat-topped hills and are underlain usually by Laguna sediments. A broad area of North Merced gravels trends southwest from Folsom. This area is at most 3 miles wide and extends nearly as far as Florin Road and Bradshaw Road.

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The North Merced gravels consist of discontinuous beds of lenticles of stream-laid detritus. This material was deposited by many rivers and streams, which drained the Sierra Nevada during the middle and latter parts of the Pleistocene Epoch. The North Merced gravels are easily distinguished from the underlying materials by the coarseness of the particles and red color of the iron oxide cement.

Laguna Formation (TI)

The Laguna Formation is exposed in the eastern and central portions of the Plan Area. The formation's eastern outcrop extends northward from Dry Creek, where its area of exposure is about 6 miles wide, to its northernmost exposure along Meiss Road. Its central outcrop extends northward from Deer Creek to its northernmost exposure along U.S. 50. This formation, ranging from late Miocene to early Pliocene in age, rests over the older Mehrten Formation. Where the Mehrten is andesitic in character and generally dark-colored, the Laguna is non-volcanic and is generally a tan to brown color. It is composed of a heterogeneous assemblage of beds of silt, clay, and sand with lenticles of gravel deposited on westward-sloping floodplains.

Valley Springs Formation (Tvs)

The Valley Springs Formation is exposed along the eastern side of the Plan Area from the southeastern corner along Dry Creek, northward to the headwaters of Carson Creek. The formation is generally exposed over an area from 1 to 2 miles in width. Its widest exposure is along Arkansas Creek, where it is exposed for 4 miles from east of Ione Road, west to the Cosumnes River.

The formation contains varying amounts of rhyolite ash, vitreous tuff, quartz sand containing abundant glass shards, and pale-colored beds of ashy clay. Frequently, sediments of the formation contain fragments of pumice, some of which may be as much as an inch in diameter. This formation varies with texture composition. There may be expansible clays present, especially in fine-grained material.

Mehrten Formation (Tm)

The Mehrten Formation is exposed discontinuously along a broad belt in the eastern portion of the Plan Area. The belt extends from the south county boundary at Dry Creek, where it is 4 miles wide, to U.S. 50, where it is less than a mile wide. In the subsurface, the Mehrten Formation extends westward from the area of outcrop at least as far west as the Sacramento River.

The Mehrten Formation is divided into two different layers. One is a sedimentary unit composed of gray to black andesitic sands, interbedded bouldery gravels, and blue to brown clay. The black sands are generally soft and well sorted. They were formed as fluvial deposits, having been derived

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from andesitic detritus washed down the slopes of the mountains. Frequently laminated, the beds of black sand are commonly about 5 feet thick, although beds of up to 20 feet or more have been reported. Associated with the black sands are beds of stream gravel containing andesitic cobbles and boulders of up to several feet in diameter and beds of brown to blue clay and silt.

The second major unit of the Mehrten Formation is the tuff breccia. This rock is very dense and hard. It is composed of angular pieces and blocks of black, gray, and red fine-grained to porphyritic andesite, which range from less than an inch to over several feet in diameter. The tuff breccia was derived from andesitic eruptions to the east in the Sierra Nevada. During these eruptions, great quantities of highly mobile ash flowed west down the then-existing stream channels and picked up blocks of andesite debris, which were incorporated into the mass. The mass spread out over the westward-sloping plains and solidified as a pavement of hard, concrete-like rock, which ranged from only a few feet to over 30 feet in thickness. Flow patterns are readily evident where the upper surface of the tuff breccia is now exposed. On this surface, soil cover is scant, with the blocks of andesite standing out in bold relief, giving the appearance of a boulder-strewn field. Run-off from precipitation is nearly 100% due to the rocky surface.

Ione Formation (Ti)

The Ione Formation is exposed in the eastern portion of the Plan Area from Jackson Highway north to U.S. 50. In most of Sacramento County, younger sediments overlie this formation. This formation is divisible into three distinct layers. The uppermost layer of the formation is composed principally of uniform graded, medium to coarse quartz sandstone. Below the sandstone is a thick bed of white clay of ceramic quality. In some areas, the clay has been stained red to yellow and, where it is intense, the clay has become iron cemented and is present as ocher. The bottom layer is composed of blue to gray clay with occasional seams of brown coal and lignite. A zone of gravel composed of quartz and metamorphic fragments is reported to be at the base of the formation. North of the American River, the Ione Formation sediments become coarser grained. To the east, the Ione Formation is apparently contemporaneous with the Auriferous gravels of the Sierra Nevada. In certain areas outside of Sacramento County, deposits of the Ione Formation merge eastward with these gravels. The origin of the Ione Formation appears to be of a deltaic and littoral, or near-shore, environment of deposition.

Modesto Formation (Lower) (Qm2)

The Modesto formation is made up of arkosic alluvium and sand with minor gravel and silt, which together form alluvial fans and abandoned channel ridges in valleys and along streams. Qm2 is unweathered alluvium that forms terraces that are topographically lower than Qm1.

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Table 4
Summary of Landforms in Plan Area by Watershed

Formation	American River	Deer Creek	Laguna Creek	Lower Cosumnes River	Lower Dry Creek	Lower Mokelumne River	Morrison Creek	Sherman Lake-Sacramento River	Snodgrass Slough	Upper Cosumnes River	Grand Total	Percent of Plan Area
Alluvium	23	829	—	<1	1,045	—	—	—	—	1,106	3,003	<1
Basin Deposits	—	—	—	3,378	—	629	597	1,500	8,548	—	14,652	5%
Chico Formation	—	52	—	—	—	—	—	—	—	—	52	<1
Copper Hill Volcanics	109	1,118	—	—	—	—	—	—	—	—	1,227	<1
Gopher Ridge Volcanics	353	7,666	—	—	—	—	—	—	—	2,076	10,096	3%
Intertidal Deposits	—	—	—	—	—	1,066	—	4,360	455	—	5,881	2%
Ione Formation	—	2,167	1,156	—	—	—	—	—	—	1,995	5,318	2%
Laguna Formation	373	3,433	21,165	5,327	3,621	—	20,718	465	—	6,181	61,282	19%
Levee and Channel Deposits	—	3,215	751	5,919	1,213	323	18	4,115	2,159	444	18,162	6%
Mehrten Formation	6	7,223	11,099	—	4,931	—	8	—	—	3,191	26,459	8%
Mine and Dredge Tailings	—	452	482	—	—	—	748	375	—	1,185	4,675	1%
Modesto Formation (Lower)	—	5,672	—	—	—	—	—	—	—	2,542	8,214	3%
Modesto-Riverbank Formation	340	175	11,343	57	2,546	—	48	179	—	—	14,688	5%
North Merced Gravel	—	—	184	—	—	—	—	—	—	—	184	<1
Riverbank Formation	504	4,583	20,340	32,001	3,781	—	20,790	2,994	29,265	7,971	122,228	38%
Salt Springs Slate	283	6,217	—	—	—	—	—	—	—	1,301	7,801	2%
Valley Springs Formation	—	987	7455	—	1,356	—	—	—	—	3,892	13,690	4%
Grand Total	3,452	43,803	73,976	46,682	18,493	2,020	42,926	13,987	40,426	31,885	317,655	100%

Note: Due to the relatively coarse scale of the land cover mapping, rounding to nearest acre is applied to acreages 10 or greater. The six acres occurring in Cache Slough are not included in the total. Any discrepancies in individual totals are due to rounding but the grand total for each watershed is consistent.

* Information is not available for the entire Plan Area.

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3.1.4 Soils in the Plan Area

There are 129 different soil mapping units within the Plan Area. In order to condense the soil types within the Plan Area, the mapping units were grouped by the surface texture attribute (e.g., loam, clay, silt) (Table 5, Figure 6). Soil mapping units that did not contain a surface texture attribute are listed under “Other Soil Types” in Table 5. Overall, the Plan Area is dominated by loam soil subsets, primarily silt loam, which accounts for about 34% of the Plan Area. The “Other Soil Types” account for less than 5% of the soil types in the Plan Area.

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Table 5
Summary of Soil Types in Plan Area by Watershed

Soil Type	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)	Grand Total (acres)	Percent of Plan Area
<i>General Soil Types</i>												
Silt Loam	43	10,939	20,230	30,367	6,366	394	15,233	1,705	12,892	9,306	107,475	34%
Gravelly Loam	104	7,498	22,038	2,335	5,251	—	8,987	41	—	7,332	53,586	17%
Loam	1,203	11,494	12,625	3,658	917	—	11,636	2,560	1,027	4,538	49,658	16%
Fine Sandy Loam	8	4,468	11,881	29	5,135	11	1,203	85	—	3,119	25,940	8%
Clay	—	536	1,462	2,771	127	1,198	2,028	1,642	13,138	920	23,821	7%
Sandy Loam	—	6,408	1,425	4,624	90	277	343	326	861	3,188	17,543	6%
Sandy Clay Loam	—	1,438	1,065	833	143	—	5	4	6,702	323	10,513	3%
Clay Loam	—	—	856	248	—	31	191	1,637	2,812	—	5,775	2%
Water	67	302	616	915	131	99	299	746	1,500	888	5,563	2%
Mucky Clay	—	—	—	—	—	—	—	3,601	92	—	3,693	1%
Loamy Sand	—	—	—	—	—	—	—	—	815	—	815	<1%
Cobbly Loam	—	—	4	—	19	—	—	—	—	—	23	<1%
Silty Clay Loam	—	—	<1	<1	16	9	—	—	—	—	25	<1%
Gravelly Silt Loam	—	21	—	—	—	—	—	—	—	—	21	<1%
Gravelly Sandy Loam	—	—	2	—	3	—	—	—	—	—	5	<1%
Coarse Sandy Loam	—	—	—	—	—	—	—	—	—	1	1	<1%

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Table 5
Summary of Soil Types in Plan Area by Watershed

Soil Type	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)	Grand Total (acres)	Percent of Plan Area
<i>Other Soil Types</i>												
Xerorthents, dredge tailings, 2% to 50% slopes	332	335	395	—	—	—	599	362	—	1,427	3,449	1%
Xerarents-San Joaquin complex, 0 to 1% slopes	—	68	896	482	109	—	463	—	60	49	2,127	1%
Urban land	41	—	136	—	—	—	903	412	—	—	1,492	<1%
Xerarents-Urban land-San Joaquin complex, 0 to 5% slopes	101	—	—	—	—	—	359	234	—	5	698	<1%
Xerorthents, dredge tailings-Urban land complex, 0 to 2% slopes	1,197	—	—	—	—	—	—	98	—	—	1,295	<1%
Pits	75	58	18	—	—	—	384	198	10	420	1,163	<1%
Urban land-Natomas complex, 0 to 2% slopes	257	—	—	—	—	—	12	221	—	—	490	<1%

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 5
Summary of Soil Types in Plan Area by Watershed

Soil Type	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)	Grand Total (acres)	Percent of Plan Area
Xerarents-Redding complex, 0 to 2% slopes	24	18	321	422	—	—	166	—	—	—	950	<1%
Fluvaquents, 0 to 2% slopes, frequently flooded	—	—	—	—	—	—	—	—	517	—	517	<1%
Slickens	—	—	—	—	—	—	26	—	—	21	47	<1%
Lithic Xerorthents, 2% to 8% slopes	—	29	—	—	184	—	—	—	—	197	410	<1%
Dumps	—	135	—	—	—	—	88	—	—	—	223	<1%
Urban land-Xerarents-Fiddyment complex, 0 to 8% slopes	—	—	—	—	—	—	—	114	—	—	114	<1%
Xerofluvents, 0 to 2% slopes, flooded	—	56	—	—	—	—	—	—	—	130	186	<1%
Riverwash	—	—	5	—	—	—	—	—	—	21	26	<1%
Mokelumne soils and alluvial land	—	—	—	—	<1	—	—	—	—	—	<1	<1%

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 5
Summary of Soil Types in Plan Area by Watershed

Soil Type	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)	Grand Total (acres)	Percent of Plan Area
Placer diggings and Riverwash	—	—	—	—	<1	—	—	—	—	—	<1	<1%
Inks loam and Rock land, 3% to 45% slopes	—	—	<1	—	—	—	—	—	—	—	<1	<1%
Grand Total	3,452	43,803	73,976	46,682	18,493	2,019	42,926	13,987	40,426	31,885	317,649¹	100%

¹ The total does not include the approximately 6 acres of the Cache Slough watershed, which is not discussed in this document.

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

3.1.5 Slope and Elevation

The topography of the Plan Area reflects the initial geological conditions as they have been modified over time by wind, rain, and flowing water. Generally, the Plan Area is dominated by flat or gently sloping terrain, and steep slopes are rare. The central and western regions of the Plan Area are dominated by flat terrain. In the eastern region, the flat terrain gives way to rolling hills (USDA NRCS 1993). Elevations range from approximately 5 feet below sea level in the southwest portion of the Plan Area to approximately 670 feet amsl in the eastern portion of the Plan Area. Because much of the Plan Area lies in low, flat terrain with little to no slope, natural drainageways in these areas are usually poorly defined and drainage of stormwater is slow. Tables 6 and 7 show a breakdown of the slopes and elevation ranges, respectively, for each watershed. These topographic features are represented on Figure 7 for elevations and Figure 8 for slopes.

Table 6
Summary of Slopes in the Plan Area

Watershed	0–20%		21%–40%		>40%		Total (acres)
	Acres	Percent	Acres	Percent	Acres	Percent	
American River	3,452	100	—	—	—	—	3,452
Deer Creek	43,467	99.2	327	0.1	8	<0.1	43,803
Laguna Creek	73,833	99.8	141	0.2	2	<0.1	73,976
Lower Cosumnes River	46,682	100	—	—	—	—	46,682
Lower Dry Creek	18,246	98.7	242	1.3	5	<0.1	18,493
Lower Mokelumne River	2,019	100	—	—	—	—	2,019
Morrison Creek	42,924	99.9	2	<0.1	—	—	42,926
Sherman Lake-Sacramento River	13,987	100	—	—	—	—	13,987
Snodgrass Slough	40,426	100	—	—	—	—	40,426
Upper Cosumnes River	31,447	98.6	405	1.3	34	0.1	31,885
Total	316,483	99.6	1,117	0.4	49	<0.1	317,649¹

¹ The total does not include the approximately 6 acres of the Cache Slough watershed, which is not discussed in this document.

Table 7
Summary of Elevation Ranges in the Plan Area

Watershed	0–500 feet		501–1,000 feet		Total (acres)
	Acres	Percent	Acres	Percent	
American River	3,385	98.1	66	2	3,452
Deer Creek	42,536	97.1	1,267	2.7	43,803
Laguna Creek	73,976	100.0	—	—	73,976
Lower Cosumnes River	46,682	100.0	—	—	46,682

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Table 7
Summary of Elevation Ranges in the Plan Area

Watershed	0–500 feet		501–1,000 feet		Total (acres)
	<i>Acres</i>	<i>Percent</i>	<i>Acres</i>	<i>Percent</i>	
Lower Dry Creek	18,451	99.8	42	0.2	18,493
Lower Mokelumne River	2,019	100.0	—	—	2,019
Morrison Creek	42,926	100.0	—	—	42,926
Sherman Lake-Sacramento River	13,987	100.0	—	—	13,987
Snodgrass Slough	40,426	100.0	—	—	40,426
Upper Cosumnes River	31,761	99.6	124	0.4	31,885
Total	316,149	99.5	1,499	0.5	317,649¹

¹ The total does not include the approximately 6 acres of the Cache Slough watershed, which is not discussed in this document.

Table 6 shows that more than 99% of the Plan Area supports slopes less than 20%, with a range of just over 98% in the Upper Cosumnes River watershed to 100% in several of the watersheds. Similarly, Table 7 shows that over 99% of the Plan Area has an elevation of less than 500 feet and that all of the watersheds have at least 97% of their elevations at less than 500 feet; only four watersheds have elevations above 500 feet. The Deer Creek watershed accounts for about 3% of the acreage in the Plan Area above 500 feet.

3.1.6 Covered Species

Occurrences of Covered Species recorded throughout the Plan Area are shown in Table 8 and are depicted on Figures 9-1 through 9-29. Generally, Table 8 shows that most of the occurrence data for Covered Species in the Plan Area are concentrated in 5 of the 10 watersheds: Morrison Creek and Laguna for the vernal pool Covered Species and Morrison Creek, Laguna, Snodgrass Slough, Upper Cosumnes River, and Lower Cosumnes River for the other Covered Species. These five watersheds combined account for 72% of the total Covered Species occurrences in the Plan Area. Descriptions of the Covered Species occurrences within the different watersheds are provided in the analyses below for each watershed. It should be noted that the Covered Species occurrence data generally reflect where the most comprehensive surveys have been conducted in the Plan Area and do not necessarily reflect negative findings elsewhere in the Plan Area. For example, most of the vernal pool Covered Species occurrences are known from existing vernal pool Preserves inside the UDA and existing Preserve in PPU 7 outside the UDA, and relatively few occurrences are from planned criteria-based conservation areas simply because many of these areas have not been surveyed.

The SSHCP also includes an analysis of potentially suitable habitat (i.e., modeled habitat) for each of the Covered Species (Table 9, Figures 9-1 through 9-29). Further, several of the

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Biological Goals and Measurable Objectives for plant species (Table 7-1, Chapter 7 of the SSHCP) prescribe that before an occurrence can be taken, one must be protected. For three Covered Species (giant garter snake, greater sandhill crane, and Swainson's hawk), the effects analysis also includes "high-value" habitat for the species in the Plan Area. High-value habitat is defined differently for each of the three species (Chapter 3 of the SSHCP), but generally refers to particularly important habitat in the Plan Area. Complete descriptions of the Covered Species are found in Chapter 3 of the SSHCP, effects of the SSHCP to Covered Species are described in Chapter 6, and the SSHC Conservation Strategy for the Covered Species is described in Chapter 7 of the SSHCP.

Similar to the Covered Species occurrences, Morrison Creek and Laguna support the majority of modeled habitat for vernal pool Covered Species, together accounting for 92% of the modeled habitat for both the vernal pool plants and vernal pool invertebrates. Modeled habitat for the other Covered Species is distributed across more watersheds, with Laguna accounting for most of the total, but with substantial modeled habitat in the Deer Creek, Lower Cosumnes River, Upper Cosumnes River, Morrison Creek, and Snodgrass Slough watersheds. More detailed descriptions of the modeled habitat for Covered Species within the different watersheds are provided in the analyses in Section 3.2 for each watershed.

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Table 8
Summary of Covered Species Occurrences Within Watersheds¹

Covered Species	Species Occurrence Total	American River	Deer Creek	Laguna Creek	Lower Cosumnes River	Lower Dry Creek	Lower Mokelumne River	Morrison Creek	Sherman Lake-Sacramento River	Snodgrass Slough	Upper Cosumnes River
<i>Vernal Pool Plants</i>											
Ahart's dwarf rush	2	—	—	—	—	—	—	2	—	—	—
Boggs Lake hedge-hyssop	30	—	3	—	—	—	—	27	—	—	—
Dwarf downingia	10	—	—	2	1	—	—	—	—	7	—
Legenere	56	—	—	2	5	1	—	30	—	12	6
Pincushion navarretia	48	—	—	32	—	16	—	—	—	—	—
Sacramento Orcutt grass	40	—	19	2	—	—	—	19	—	—	—
Slender Orcutt grass	4	—	—	—	—	—	—	4	—	—	—
Occurrences in Watershed	190	0	22	38	6	17	0	82	0	19	6
<i>Non-Vernal Pool Plant</i>											
Sanford's arrowhead	63	—	2	—	4	—	3	12	2	35	5
<i>Vernal Pool Invertebrates</i>											
Vernal pool fairy shrimp	572	—	14	305	8	10	—	196	2	17	20
Vernal pool tadpole shrimp	748	2	16	187	3	5	—	505	2	21	7
Ricksecker's water scavenger beetle	4	—	—	3	1	—	—	—	—	—	—
Mid-valley fairy shrimp	33	—	—	5	1	—	—	18	—	9	—
Occurrences in Watershed	1,357	2	30	500	13	15	0	719	4	47	27

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 8
Summary of Covered Species Occurrences Within Watersheds¹

Covered Species		Species Occurrence Total	American River	Deer Creek	Laguna Creek	Lower Cosumnes River	Lower Dry Creek	Lower Mokelumne River	Morrison Creek	Sherman Lake-Sacramento River	Snodgrass Slough	Upper Cosumnes River
<i>Wildlife</i>												
<i>Amphibians/Reptiles</i>												
California tiger salamander		29	—	—	23	—	6	—	—	—	—	—
Giant garter snake		14	—	—	1	5	—	—	1	—	7	—
Western pond turtle		18	—	1	8	2	—	—	2	—	5	—
Western spadefoot		31	—	1	18	—	1	—	9	—	—	2
<i>Birds</i>												
Burrowing owl		90	1	4	23	14	—	—	26	6	16	—
Cooper's hawk		17	—	2	1	6	—	—	4	—	2	2
Ferruginous hawk		26	—	4	6	3	—	—	8	—	2	3
Loggerhead shrike		30	—	4	6	8	—	—	3	—	7	2
Northern harrier		62	1	6	7	20	1	—	9	2	13	3
Greater sandhill crane	All data	3,249	—	—	390	642	259	—	2	1,205	722	29
	Roosts	48	—	—	7	29	—	—	—	—	12	—
Swainson's hawk	All data	398	1	31	51	107	19	—	20	8	127	34
	Nests	293	—	22	42	90	15	—	11	3	86	24
Tricolored blackbird	All data	305	3	45	91	33	2	—	87	5	6	33
	Documented nests	36	—	6	5	3	—	—	20	—	1	1
White-tailed kite		58	—	4	1	23	—	—	13	4	10	3

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 8
Summary of Covered Species Occurrences Within Watersheds¹

Covered Species	Species Occurrence Total	American River	Deer Creek	Laguna Creek	Lower Cosumnes River	Lower Dry Creek	Lower Mokelumne River	Morrison Creek	Sherman Lake-Sacramento River	Snodgrass Slough	Upper Cosumnes River
<i>Invertebrates</i>											
Valley elderberry longhorn beetle	156	1	1	—	1	—	—	—	—	—	153
<i>Mammals</i>											
American badger	8	—	—	—	—	—	—	7	—	1	—
Western red bat	7	—	—	2	—	—	—	2	2	—	1
All Wildlife Species in Watershed²	4,561	7	105	628	868	288	3	205	1,234	953	270
Total Covered Species in Watershed²	6,108	9	157	1,166	887	320	3	1,006	1,238	1,019	303

¹ The occurrence data reported in this table include all documented observations for the Covered Species in the Plan Area. Nest or roost sites are included for Swainson's hawk, tricolored blackbird, and greater sandhill crane.

² Totals and percentages are based on sums of all occurrence data and do not include subtotals for nests or roosts for Swainson's hawk, tricolored blackbird, and greater sandhill crane, which are subsets of all occurrence data for these species.

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 9
Modeled Habitat for Covered Species within a Watershed

Covered Species		Total Acres of Modeled Habitat ^{1,2}	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)
<i>Vernal Pool Plants (general habitat model in acres)</i>												
Ahart's dwarf rush		25,135	126	2,954	6,689	1,269	327	—	10,974	19	2777	
Boggs Lake hedge-hyssop		37,001	183	3,908	8,663	4,954	484	—	12,702	67	815	5,225
Dwarf downingia		24,260	-	1,310	10,991	4,341	1,947	—	2,218	—	1,362	2,091
Legenere		50,971	156	4,174	16,491	6,210	2,107	—	15,118	137	1,679	4,899
Pincushion navarretia		57,437	79	8,242	29,570	1,408	6,351	—	6,841	7.33	—	4,939
Sacramento Orcutt grass		34,491	125	3951	14,275	1,371	2,005	—	9,972	19	—	2,774
Slender Orcutt grass		34,491	125	3,951	14,275	1,371	2,005	—	9,972	19	—	2,774
<i>Non-Vernal Pool Plant</i>												
Sanford's arrowhead		52,824	133	5,124	12,535	9,713	773	13	15,026	41	2,817	6,648
<i>Vernal Pool Invertebrates</i>												
Vernal pool fairy shrimp/Vernal pool tadpole shrimp	General	103,210	378	13,814	40,030	10,004	7,131	—	18,445	326	1,918	11,163
Ricksecker's water scavenger beetle	General	103,436	378	13,795	40,030	10,004	7,131	—	18,390	326	1,918	11,163
Mid valley fairy shrimp	General	53,698	208	5,705	13,594	7,412	770		16,907	309	1,852	6,941

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 9
Modeled Habitat for Covered Species within a Watershed

Covered Species		Total Acres of Modeled Habitat ^{1,2}	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)
<i>Amphibians/Reptiles</i>												
California tiger salamander	Upland	85,369	—	—	46,092	13,807	9,911	—	—	—	—	15,559
	Aquatic	4,424	—	—	2,336	1,070	319	—	—	—	—	699
Giant garter snake	Aquatic	7,290	—	3	697	2,430	1	91	441	66	3,559	2
	Upland	27,868	—	181	9,521	8,934	19	3	3,258	114	5,760	78
	High Value ³	10,481	—	—	1,170	1,518	10	0.4	1,388	45	6,350	—
Western pond turtle	Breeding/Foraging	6,355	10	392	739	1,866	132	91	515	7	2,005	599
	Nesting/Aestivation	110,846	899	25,697	33,739	11,195	8,273	199	8,750	425	6,517	15,153
Western spadefoot	Aquatic	13,478	41	1,011	3,477	2,387	471	71	1,566	23	2,987	1,444
	Upland	149,862	1,318	30,062	46,092	14,593	9,911	—	21,312	627	5,945	20,002
<i>Birds</i>												
Burrowing owl	Nesting/Foraging	204,644	1,336	30,562	55,756	30,654	11,553	1,679	24,956	1,704	25,499	20,945
Cooper's hawk	Foraging	5,637	-	2,018	2,550	—	529	—	18	—	—	521
	Nesting	17,010	48	5,357	1,846	2,231	1,865	199	487	182	1,767	3,028
Ferruginous hawk	Foraging	159,612	1,369	25,055	50,046	19,420	8,701	9	23,951	633	10,452	19,976
Loggerhead	Foraging	72,405	32	5,476	13,826	17,440	3,478	1,679	4,903	1,084	20,767	3,719

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 9
Modeled Habitat for Covered Species within a Watershed

Covered Species		Total Acres of Modeled Habitat ^{1,2}	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)
shrike	Foraging/ Nesting	135,112	1,336	23,643	42,178	14,593	7,965	0.13	21,294	626	5,945	17,530
	Nesting	7,878	48	957	481	2,231	448	199	487	182	1,767	1,078
Northern harrier	Foraging	11,309	34	602	2,931	2,506	432	21	1,600	14	2,243	926
	Foraging/ Nesting	199,008	1,336	28,544	53,205	30,654	11,023	1,679	24,938	1,704	25,499	20,424
Greater Sandhill crane	Roosting	1,156	—	8	279	369	28	—	17	—	421	734
	Foraging	84,286	—	3,677	16,315	29,301	3,289	1,421	1,593	855	25,438	2,398
	Foraging/ Roosting	4,322	—	46	336	1,696	48	21	315	8	1,811	43
	High Value	81,473	—	2,569	14,103	30,527	2,599	1,442	75	836	26,848	2,474
Swainson's hawk	Foraging	205,988	1,303	27,862	55,969	32,033	11,408	1,679	26,168	1,711	26,712	21,142
	Nesting	7,237	—	916	323	2,214	448	199	358	180	1,767	832
	High Value ³	75,534	—	3,177	10,092	25,942	1,942	1,878	1,926	1,356	28,340	881
Tricolored blackbird	Foraging	24,244	12	1,482	7,747	4,874	627	12	2,710	16	4,446	2,318
	Nesting- Foraging	188,539	1,361	27,875	48,721	28,950	10,871	1,692	24,016	1,712	24,016	19,324
White-tailed kite	Foraging	213,154	1,369	31,138	58,554	32,033	11,972	1,679	26,215	1,711	26,712	21,771
	Nesting	17,010	48	5,357	1,846	2,231	1,865	199	487	182	1,767	3,028

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Table 9
Modeled Habitat for Covered Species within a Watershed

Covered Species		Total Acres of Modeled Habitat ^{1,2}	American River (acres)	Deer Creek (acres)	Laguna Creek (acres)	Lower Cosumnes River (acres)	Lower Dry Creek (acres)	Lower Mokelumne River (acres)	Morrison Creek (acres)	Sherman Lake-Sacramento River (acres)	Snodgrass Slough (acres)	Upper Cosumnes River (acres)
<i>Invertebrates</i>												
Valley elderberry longhorn beetle	General	7,878	48	957	481	2,231	448	199	487	182	1,767	1,078
<i>Mammals</i>												
American badger	General	149,136	1,369	26,225	47,492	15,972	8,879	—	22,542	633	7,158	18,866
Western red bat	Foraging	152,890	1,379	24,754	45,883	18,392	8,531	94	23,376	787	10,508	19,186
	Roosting/Foraging	24,841	48	7,432	4,946	2,062	2,559	196	504	1,540	1,874	3,679

¹ Total modeled habitat acreages for a species include areas where different models (e.g., foraging and breeding) for the species overlap (i.e., the acreages in the models for a particular species are not mutually exclusive).

² Modeled habitat totals may not sum exactly to the modeled habitat acreages reported in the SSHCP due to rounding error.

³ High-value habitat is a subset of modeled habitat and is included in the total modeled habitat acreage.

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3.1.7 Preserve Design

The majority of conservation, existing and planned, within the Plan Area will occur within the Laguna Creek watershed, while very little conservation is designated within the American River watershed (Table 10, Figure 10). Watersheds with approximately 22% to 24% of existing conservation include Lower Dry Creek, Lower Cosumnes River, and Snodgrass Slough. Substantial conservation is planned for 7 of the 10 watersheds, ranging from approximately 2,571 acres in Deer Creek to approximately 5,119 acres in Lower Cosumnes River. Ultimately, Laguna Creek watershed would have the highest total conservation by percentage at almost 27% and by acreage at more than 25,633 acres.

Table 10
Summary of Watershed Conservation

Watershed	Plan Area Total		Existing Conservation		Planned Conservation		No Conservation		Percentage of Conservation in Plan Area
	Acre	% of Plan Area	Acre	% of Watershed	Acre	% of Watershed	Acre	% of Watershed	
American River	997	0.4	0	0	0	0.0	997	0.6	0%
Deer Creek	34,971	13.5	5,464	8.5	2,571	7	26,936	17	23%
Laguna Creek	69,633	26.8	18,356	28.5	14,513	39.4	36,764	23	47%
Lower Cosumnes River	44,411	17	14,266	22	5,119	13.9	25,026	15.8	44%
Lower Dry Creek	17,661	6.8	8,834	13.7	358	1	8,470	5.3	52%
Lower Mokelumne River	2,019	0.8	1,642	2.5	0	0.0	377	0.2	81%
Morrison Creek	10,007	3.9	2,888	4.8	5,883	16	1,236	0.8	88%
Sherman Lake-Sacramento River	9,737	3.7	758	1.8	103	0.3	8,876	5.6	9%
Snodgrass Slough	38,806	15	8,943	13.9	5,497	14.9	24,366	15.4	37%
Upper Cosumnes River	31,602	12	3,368	5.2	2,803	7.6	25,429	16	20%
Total	259,849	—	64,519	24.8	36,847	14.2	158,483	61	100

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Table 11 provides a breakdown of the watersheds by non-UDA/UDA areas and PPUs. All but the Upper Cosumnes and Lower Mokelumne River watersheds intersect both the UDA and non-UDA areas and all intersect more than one PPU. Section 3.3 provides descriptions of the watersheds and how they relate to Preserve planning inside and outside the UDA and by PPUs.

Table 11
Summary of Preserve Planning Units by Watershed

Watershed		Outside of Preserve Planning Units (acres)	PPU 1 (acres)	PPU 2 (acres)	PPU 3 (acres)	PPU 4 (acres)	PPU 5 (acres)	PPU 6 (acres)	PPU 7 (acres)	PPU 8 (acres)	Total (acres)
American River	Non-UDA	1,094	—	—	—	—	—	—	—	—	1,094
	UDA	—	1,106	1,251	—	—	—	—	—	—	2,357
Deer Creek	Non-UDA	8,081	—	—	—	—	21,005	2,435	—	—	31,521
	UDA	—	8,150	—	3,003	1,130	—	—	—	—	12,283
Laguna Creek	Non-UDA	—	—	—	—	—	—	8,292	61,441	—	69,733
	UDA	—	—	—	—	—	—	—	—	4,242	4,242
Lower Cosumnes River	Non-UDA	—	—	—	—	—	4,941	31,008	8,942	—	44,891
	UDA	—	—	—	—	—	—	—	—	1,791	1,791
Lower Dry Creek	Non-UDA	—	—	—	—	—	—	1,218	16,176	—	17,394
	UDA	—	—	—	—	—	—	—	—	1,099	1,099
Lower Mokelumne River	Non-UDA	—	—	—	—	—	—	2,019	—	—	2,019
	UDA	—	—	—	—	—	—	—	—	—	—
Morrison Creek	Non-UDA	70	—	—	—	—	—	111	—	—	181
	UDA	12,210	10,146	6,028	11,301	3,060	—	—	—	—	42,745
Sherman Lake-Sacramento River	Non-UDA	—	—	—	—	—	—	9,737	—	—	9,737
	UDA	1,876	326	1,992	—	57	—	—	—	—	4,251
Snodgrass Slough	Non-UDA	—	—	—	—	—	—	39,420	—	—	39,420
	UDA	—	—	—	—	1,006	—	—	—	—	1,006

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Table 11
Summary of Preserve Planning Units by Watershed

Watershed		Outside of Preserve Planning Units (acres)	PPU 1 (acres)	PPU 2 (acres)	PPU 3 (acres)	PPU 4 (acres)	PPU 5 (acres)	PPU 6 (acres)	PPU 7 (acres)	PPU 8 (acres)	Total (acres)
Upper Cosumnes River	Non-UDA	—	—	—	—	—	26,602	935	4,348	—	31,885
	UDA	—	—	—	—	—	—	—	—	—	—
Total		23,330	19,729	9,271	14,303	5,253	52,549	95,182	90,906	7,132	317,655

3.2 Description of Watersheds in Plan Area

3.2.1 American River Watershed

3.2.1.1 Land Cover Types

Approximately 3,452 acres, or about 5%, of the 65,103-acre American River watershed is located within the Plan Area. This watershed comprises 1% of the entire Plan Area and is located in the northern portion of the Plan Area (Figure 2). A little more than half of the watershed contains Non-habitat land cover types, which primarily includes high-density development and mine tailings (Table 2, Figure 3). The remaining undeveloped land consists of Valley Grassland, Mine Tailing Riparian Woodland, Mixed Riparian Woodland, Blue Oak Woodland, and Savanna and Mixed Riparian scrub. Aquatic resources account for only approximately 98 acres, or about 3%, of the American River watershed. Impervious surfaces cover approximately 1,773 acres, or 51%, of the watershed within the Plan Area. Along with the Morrison Creek (16% impervious surfaces) and Sherman Lake-Sacramento River (24% impervious surfaces) watersheds, the American River watershed has one of the three highest percentages of impervious surfaces in the Plan Area.

3.2.1.2 Hydrology

According to the NHD flowline dataset, the American River watershed contains about 1% of the Plan Area's flowline features. Alder and Buffalo Creeks are the main water sources within this watershed, both of which are tributaries to the American River located north of the Plan Area.

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Artificial paths (48%) and streams/rivers (46%) account for most of the flowline features in the American River watershed.

3.2.1.3 Geological Formations

The majority of the American River watershed is comprised of riverbank formations, Laguna formation and gopher ridge volcanics (45%) (Table 4, Figure 5).

3.2.1.4 Soils

The majority of this watershed (59%) contains dredge tailings, pits, and other remnants from mining operations (Table 5, Figure 6). The remaining acreage consists mostly of loam (35%) and gravelly loam (about 3%) soils.

3.2.1.5 Slope and Elevation

The entire American River watershed contains flat to gentle slopes (0-20%). (Table 6, Figure 7). This watershed does not contain any lands above 20% slopes. Similarly, the majority of the watershed is between an elevation range of 0-500 feet, with only about 2% ranging from 500-1,000 feet (Table 7, Figure 8).

3.2.1.6 Covered Species

The American River watershed includes documented occurrences for 10 of the 28 Covered Species, including: tricolored blackbird (*Agelaius tricolor*), Swainson's hawk (*Buteo swainsoni*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), vernal pool tadpole shrimp (*Lepidurus packardii*), burrowing owl (*Athene cunicularia*), and northern harrier (*Circus cyaneus*) (Table 8). However, about 45% of the American River watershed has been influenced by human activities with about half of the watershed dominated by non-habitat land covers and agriculture (Table 2, Figure 3). Subsequently, in combination with making up only 1% of the Plan Area, the portions of the American River watershed within the Plan Area do not support a high overall percentage of the Covered Species occurrences in the Plan Area.

Modeled habitat for several species occurs within this watershed, with substantial amounts of modeled habitat for the covered bird and mammal species (Table 9). Except for Cooper's hawk and greater sandhill crane (*Grus canadensis*), whose modeled habitat is limited to the western portion of the Plan Area, the American River watershed supports more than 1,000 acres of modeled habitat for each of the covered bird and mammal species, including more than 1,384 acres of nesting habitat for loggerhead shrike (*Lanius ludovicianus*) and foraging habitat for Cooper's hawk, more than 1,336 acres of nesting/foraging habitat for burrowing owl, and more

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than 5,455 acres of foraging habitat for ferruginous hawk (*Buteo regalis*), loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, and white-tailed kite. The watershed contains more than 1,361 acres of modeled nesting habitat for tricolored blackbird and a nesting colony of approximately 3,900 birds was observed in 2000. The watershed supports about 1,379 acres of foraging habitat and more than 48 acres of roosting habitat for western red bat, and more than 1,369 acres of modeled general habitat for American badger (*Taxidea taxus*). The watershed also contains about 48 acres of modeled habitat for valley elderberry longhorn beetle, but only one documented occurrence for the species. The watershed supports very small amounts of modeled habitat for the vernal pool Covered Species, ranging from no modeled habitat for dwarf downingia (*Downingia pusilla*) to 156 acres for legenera (*Legenera limosa*). For amphibians and reptiles, the watershed supports about 51 acres of modeled breeding habitat and 1,318 acres of modeled aestivation habitat for western spadefoot (*Spea hammondi*) and 10 acres of modeled breeding/foraging habitat and 899 acres of modeled aestivation/nesting habitat for western pond turtle (*Actinemys marmorata*). The watershed does not have modeled habitat for California tiger salamander (*Ambystoma californiense*) and giant garter snake (*Thamnophis gigas*) because it is outside the geographic range of these two species in the Plan Area. The watershed contains only 133 acres of modeled habitat for Sanford's arrowhead (*Sagittaria sanfordii*).

3.2.1.7 Conservation Considerations

Almost the entire American River watershed is located within the UDA. The 2,358 acres of this watershed within the UDA are split about equally between PPU 1, and PPU 2. Due to its relative lack of vernal pools and vernal pool Covered Species occurrences, the watershed is not considered an important component of the Conservation Strategy inside the UDA. While the American River watershed supports substantial modeled habitat for covered birds and mammals (generally more than 1,000 acres for each), these species are widespread in the Plan Area and the watershed supports a relatively small percentage (generally less than 2%) of the total modeled habitats for these species in the Plan Area. No planned Preserve components are located within this watershed and it is anticipated that much of PPU 2 will eventually be urbanized.

3.2.2 Deer Creek Watershed

3.2.2.1 Land Cover Types

The Deer Creek watershed bisects the Plan Area, extending from the northeastern edge to halfway into the Plan Area (Figure 2). Of the 81,504 acres of the watershed, 43,803 acres (54%) are within the Plan Area (Table 1). A large majority (94%) of the watershed contains "Habitat" land covers, which includes Agriculture (Table 2, Figure 3). Terrestrial land covers (31,018 acres and 71% of the watershed), consisting primarily of Valley Grassland (23,643 acres and 54% of the

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watershed), account for the majority of the watershed. Other terrestrial land covers include Blue Oak Savanna and Woodland (9% of the watershed) and Mixed Riparian Woodland, Mixed Riparian Scrub, and Mine Tailing Riparian Woodland (2% of the watershed). Approximately 21% (9,269 acres) of the watershed consists of lands used for agricultural purposes and 6% (2,467 acres) fall under the Non-habitat land cover type. The remaining 2% of the watershed (1,048 acres) consists of aquatic resources such as streams and creeks, open water, and vernal pools. Impervious surfaces cover approximately 188 acres, or less than 1%, of the watershed within the Plan Area.

3.2.2.2 Hydrology

Approximately 86% of the NHD data within the Deer Creek watershed contains streams and rivers (Table 3, Figure 4). Deer Creek and its tributaries are the central focus of this watershed. Notable tributaries located within the watershed include Crevis Creek, Carson Creek, and Coyote Creek. The Cosumnes River separates the Deer Creek watershed from the Upper Cosumnes River watershed (see Section 3.2.10). Artificial paths account for about 6% of this watershed, with the majority related to the southern extension of the Folsom South Canal. The remaining NHD features within the Deer Creek watershed are canal/ditch (7%), connector (less than 1%), and pipeline (less than 1%).

3.2.2.3 Geological Formations

Gopher ridge volcanics, Mehrten formation and salt springs slate underlie the majority of the Deer Creek watershed, accounting for about 48% (Table 4, Figure 5). Several other geological formations are prominent within this watershed and include laguna formation, levee and channel deposits, Modesto formation, and riverbank formation.

3.2.2.4 Soils

A wide variety of loam subcategories occur within this watershed (Table 5, Figure 6): loam (26%), silt loam (25%), gravelly loam (17%), sandy loam (15%), fine sandy loam (10%), and sandy clay loam (3%). Additional soils include clay (1%) and soils listed in the other category (2%). A small percentage (less than 1%) includes areas covered in water.

3.2.2.5 Slope and Elevation

The Deer Creek watershed contains slopes from 0 to greater than 40%, with the vast majority of the slopes (99%) within the 0-20% category (Table 6, Figure 7). Less than 1% are within the 20%-40% and less than 1% are within the greater than 40% category. The majority of the steep slopes are concentrated along the portion of Deer Creek River located in the northeastern section

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of the watershed. Of all the watersheds, Deer Creek contains the highest percentage (3%) of acreage within an elevation range of 500-1,000 feet (Table 7, Figure 8). This acreage is concentrated along the eastern border of the Plan Area.

3.2.2.6 Covered Species

The Deer Creek watershed includes documented occurrences for 16 of the 28 Covered Species, including: Boggs Lake hedge-hyssop, Sacramento Orcutt grass (*Orcuttia viscida*), Sanford's arrowhead, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, valley elderberry longhorn beetle, vernal pool fairy shrimp, vernal pool tadpole shrimp, western pond turtle, western spadefoot, and white-tailed kite (Table 8). This watershed contains 2% of the known occurrences for these 16 Covered Species, and contains a substantial percentage of occurrences for two of the Covered Species, including 48% of the Sacramento Orcutt grass records and 15% of the ferruginous hawk records. Covered species have been recorded throughout the watershed, with the majority occurring along hydrologic features and within aquatic or terrestrial habitat. A cluster of vernal pool species records occur along the border of Deer Creek and Morrison watersheds east of the intersection of Grant Line Road and Keifer Boulevard.

Consistent with the occurrence of several vernal pool species, the Deer Creek watershed contains modeled habitat for all of the vernal pool Covered Species, ranging from 1,310 for dwarf downingia to 13,814 acres for vernal pool fairy shrimp and vernal pool tadpole shrimp (Table 9). The Deer Creek watershed contains substantial acreages of modeled habitats for all of the covered bird species, including 602 acres to well over 30,000 acres (64% of the watershed) of modeled foraging habitat for Cooper's hawk, loggerhead shrike, northern harrier, ferruginous hawk, Swainson's hawk, tricolored blackbird, white-tailed kite, and burrowing owl. The watershed also supports large amounts of nesting habitat for many of the covered birds, including more than 30,562 acres for burrowing owl (including foraging habitat), and about 5,357 acres for white-tailed kite. Of the 398 documented Swainson's hawk nest sites, 31 are in the Deer Creek watershed. The watershed also supports 3,177 acres of high-value foraging habitat for Swainson's hawk.

Fifteen of the 96 documented nest colonies for tricolored blackbird and 5 of 63 potential nest colonies are in the watershed. Approximately 14,280 individuals have been observed at the 96 documented nest colonies over the survey years, or 9% of the total individuals observed at nest colonies in the Plan Area. Nest colonies in this watershed have ranged from 30 to approximately 3,500 individuals.

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The watershed is important for western spadefoot and western pond turtle, supporting almost 1,011 acres of modeled breeding habitat and almost 30,062 acres of modeled aestivation habitat for western spadefoot (both habitats provide foraging habitat as well) and more than 392 acres of breeding/foraging habitat and more than 25,697 acres of modeled nesting/aestivation habitat for western pond turtle. The Deer Creek watershed does not support modeled habitat for California tiger salamander because it is outside the species' range in the Plan Area, and supports only a small amount of modeled habitat for giant garter snake (3 acres of foraging and 181 acres of upland habitat), whose populations occur in the western portion of the Plan Area.

The Deer Creek watershed supports large acreages of modeled habitat for the covered mammals, including more than 26,225 acres of modeled general habitat for American badger and about 24,754 acres of modeled foraging habitat for western red bat (*Lasiurus blossevillii*). The watershed supports about 7,432 acres of roosting habitat for the western red bat.

The Deer Creek watershed supports a relatively small amount of modeled habitat for Sanford's arrowhead (5,124 acres, or 10% of the total in the Plan Area).

3.2.2.7 Conservation Considerations

The Deer Creek watershed supports substantial biological resources and is an important component of the SSHCP Conservation Strategy, as described in the previous section. Approximately 35% of the Deer Creek watershed is located outside of the UDA, and spans over PPUPPUs, 5 and 6 (Table 11). About 48% of the watershed in the Plan Area is within PPU 5. The Deer Creek watershed includes existing and planned conservation both inside and outside of the UDA. Existing conservation (5,463 acres) occur in a patchy distribution throughout the Deer Creek watershed, with the largest existing Preserve (about 4,490 acres) located immediately north of Rancho Murieta (Figure 10). Planned conservation totals about 2,570 acres and will focus primarily on linkage Preserves, riparian and wetland restoration (see Chapter 7 of the SSHCP). Restoration activities will be focused along the Cosumnes River. Implementation of the SSHCP would result in an integrated system of large Preserves connected by linkage Preserves (Chapter 7 of the SSHCP).

The majority of existing conservation within the Deer Creek watershed targets two terrestrial land covers: blue oak woodland and valley grassland, which together would account for about 78% of the total conservation in the watershed (Table 12). Agricultural areas will also be conserved, including about 914 acres of croplands and irrigated pasture-grassland that provide foraging habitat for several of covered bird species and western red bat. About 281 acres of aquatic habitat would conserved, with most comprised of vernal pool and swale.

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Table 12
Summary of Conserved Land Cover Types in the Deer Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Blue Oak Savanna	73	—	73
Blue Oak Woodland	1,423	—	1,423
Mine Tailing Riparian Woodland	<1	—	<1
Mixed Riparian Scrub	1	14	15
Mixed Riparian Woodland	44	312	356
Valley Grassland	2,854	1,609	4,463
<i>Terrestrial Total</i>	<i>4,395</i>	<i>1,935</i>	<i>6,330</i>
<i>Aquatic</i>			
Streams/Creeks (VPIH)	<1	14	14
Freshwater Marsh	7	1	8
Open Water	6	10	16
Seasonal Wetland	5	15	20
Streams/Creeks	28	25	53
Swale	16	16	32
Vernal Pool	104	34	138
<i>Aquatic Total</i>	<i>166</i>	<i>115</i>	<i>281</i>
<i>Agriculture</i>			
Cropland	596	318	914
Irrigated Pasture-Grassland	138	37	175
Orchards	1	4	5
Vineyards	116	51	167
<i>Agriculture Total</i>	<i>851</i>	<i>410</i>	<i>1,261</i>
<i>Non-Habitat Land Cover Type</i>			
Disturbed	2	72	74
Low-density Development	27	33	60
Major Roads	12	5	17
Mine Tailings	10	—	10
<i>Non-Habitat Land Cover Type Total</i>	<i>51</i>	<i>110</i>	<i>161</i>
Grand Total	5,463	2,570	8,033

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

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3.2.3 Laguna Creek Watershed

3.2.3.1 Land Cover Types

The Laguna Creek watershed is approximately 96,788 acres, of which 73,976 acres are within the Plan Area, and comprises 76% of the Plan Area (Table 1). It is located in the southeastern portion of the Plan Area (Figure 2) and contains virtually all of the mapped land cover types in the Plan Area (Table 2, Figure 3). The large majority (91%) of the Laguna Creek watershed is undeveloped. Combined, Valley Grassland, Blue Oak Savanna, and Blue Oak Woodland account for 62% (approximately 46,092 acres) of the land covers in the watershed, and 68% of the natural land covers, including Agriculture. Agriculture accounts for 24% (approximately 17,445 acres) of the land covers in the Plan Area. The Laguna Creek watershed also supports all of the aquatic cover types except Streams/Creeks (VPIH), including approximately 2,764 acres of Vernal Pool, Seasonal Wetland, and Swale, approximately 416 acres of Streams/Creeks, and almost 300 acres of Open Water. Non-habitat land cover types comprise only 9% of the watershed, with Low-Density Development accounting for 68% of the Non-habitat land cover types. Impervious surfaces cover approximately 1,417 acres, or only 2%, of the watershed within the Plan Area.

3.2.3.2 Hydrology

According to the NHD flowline dataset, the Laguna Creek watershed contains almost 26% of the flowline types in the Plan Area, which is slightly higher than its total proportion (20%) of the Plan Area (Table 3, Figure 4). Reflecting the dominance of natural land cover types in the watershed, approximately 86% of the Laguna Creek watershed is stream/river, with artificial paths and canal/ditch accounting for almost all of the remaining 14%.

The main streams/rivers in the Laguna Creek watershed include Laguna Creek (south), which flows west from outside the Plan Area and drains to the Cosumnes River in the western portion of the watershed. Browns, Hadselville, Griffith, and Skunk Creeks all drain into Laguna Creek, with each having various tributaries creating a rich network of drainages in the watershed.

3.2.3.3 Geological Formations

The Laguna Creek watershed is underlain mostly by the laguna formation and the riverbank formation 56% of the watershed (Table 4). Other prominent formations in the watershed include the Mehrten formation and the modesto-riverbank formation.

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3.2.3.4 Soils

Approximately 95% of the soil types located within the Laguna Creek watershed are loam subcategories with the majority of the soil type consisting of gravelly loam, silt loam, loam, and fine sandy loam (Table 5, Figure 6).

3.2.3.5 Slope and Elevation

The vast majority (more than 99%) of the Laguna Creek watershed is on flat to gentle slopes 0-20%, with only 141 acres on 21%-40% slopes and 2 acres on slopes greater than 40% (Table 6, Figure 7). Likewise, the entire watershed is at an elevation less than 500 feet (Table 7, Figure 8). In the Laguna Creek watershed, elevations range from about 250 feet amsl in the hillier areas in the eastern portion of the watershed to less than 15 feet amsl in the western portion of the watershed where Laguna Creek (south) drains into the Cosumnes River.

3.2.3.6 Covered Species

The Laguna Creek watershed includes documented occurrences for 23 of the 28 Covered Species, reflecting both its large size and diversity of land cover types (Table 8). Covered species documented in the watershed include dwarf downingia, legenera, pincushion navarretia (*Navarretia myersii* ssp. *myersii*), Sacramento Orcutt grass, vernal pool fairy shrimp, Ricksecker's water scavenger beetle, vernal pool tadpole shrimp, mid-valley fairy shrimp, California tiger salamander, western spadefoot, western pond turtle, giant garter snake, Cooper's hawk, burrowing owl, loggerhead shrike, northern harrier, ferruginous hawk, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, and western red bat.

This watershed has the second highest percentage (19%) of known occurrences for Covered Species after the Sherman-Lake Sacramento River watershed (see Section 3.2.8), including 20% of the vernal pool covered plant occurrences and 37% of the vernal pool invertebrate occurrences (Table 8). The majority of pincushion navarretia (67%), California tiger salamander (79%), and western spadefoot (58%) occurrences in the Plan Area are in this watershed. Approximately 53% of the Plan Area's vernal pool fairy shrimp occurrences and 25% of the vernal pool tadpole shrimp occurrences are in valley grassland and vernal pool land covers located in the northeastern section of the watershed. Three of the four Ricksecker's water scavenger beetle occurrences in the SSHCP database occur in the Laguna Creek watershed. The watershed includes relatively high percentages of occurrences for several other Covered Species, including burrowing owl (26%), ferruginous hawk (23%), tricolored blackbird (30%), and western red bat (29%).

Due to its large size and number of land cover types, of the 10 watersheds in the Plan Area, the Laguna Creek watershed contains among the largest acreages of modeled habitat for most

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Covered Species, except for giant garter snake, which generally occurs in the western portion of the Plan Area (Table 9).

Consistent with the occurrence of all the vernal pool Covered Species, the Laguna Creek watershed contains substantial modeled habitat for these species, ranging from 6,689 acres for Ahart's dwarf rush to 10,004 acres for the vernal pool invertebrates (Table 9).

The Laguna Creek watershed contains substantial acreages of modeled habitats for all of the covered bird species, including almost 2,550 acres of modeled foraging habitat for Cooper's hawk and 2,931 to 58,554 acres (4%-79% of the watershed) of modeled foraging habitat for ferruginous hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, and white-tailed kite and modeled nesting/foraging habitat for burrowing owl. The watershed supports approximately 16,315 acres of modeled foraging habitat and 279 acres of modeled roosting habitat for greater sandhill crane. The watershed also supports large amounts of modeled nesting habitat for covered birds that can use a variety of more broad-scale land cover types for nesting (e.g., valley grassland, agriculture), including burrowing owl (55,756 acres), loggerhead shrike (42,659 acres), northern harrier (53,630 acres), and tricolored blackbird (48,721). However, for covered birds that are limited to riparian and woodland habitats for nesting, the Laguna Creek watershed supports more modest acreages of modeled nesting habitat relative to its large size, including 1,846 acres for Cooper's hawk and white-tailed kite and 323 acres for Swainson's hawk.

Of the 293 documented Swainson's hawk nest sites, 42 are in the Laguna Creek watershed. The Laguna Creek watershed supports 10,092 acres of high-value foraging habitat for Swainson's hawk. The watershed also supports 7 of the 48 documented roosting sites for the greater sandhill crane in the Plan Area.

Along with the Morrison Creek watershed, the Laguna Creek watershed supports the largest number of documented and potential tricolored blackbird nest colonies in the Plan Area (Table 8), with 20 of 96 documented nest colonies and 27 of 63 potential nest colonies in the watershed. The 20 documented nest colonies have ranged in size from approximately 20 individuals (1 site) to 6,750 individuals (1 site) observed in 1999 and have totaled about 22,630 individuals over the various surveys (14% of the approximately 158,330 individuals observed at all documented nest colonies).

The Laguna Creek watershed is extremely important for California tiger salamander and western spadefoot, and also provides substantial habitat for western pond turtle. As noted above, 76% of the occurrences (23 of 29) of the California tiger salamander are in the Laguna Creek watershed. Reflecting the habitat model parameters for the species (i.e., areas limited to south of the Cosumnes River), 49% of modeled aestivation habitat and 53% of the modeled

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breeding/foraging habitat in the Plan Area are in the Laguna Creek watershed (Table 9). For western spadefoot, along with 58% of the documented occurrences (18 of 31), the Laguna Creek watershed supports 3,477 acres of modeled breeding habitat and 46,092 acres of modeled aestivation habitat. For western pond turtle, along with 45% of the documented occurrences (8 of 18), the Laguna Creek watershed supports 739 acres of modeled breeding/foraging habitat and 33,739 acres of modeled nesting/aestivation habitat. The Laguna Creek watershed has some value for giant garter snake, but is not as critical for this species compared to the Lower Cosumnes River (Section 3.2.4), Morrison Creek (Section 3.2.7), and Snodgrass Slough (Section 3.2.9) watersheds. There is one documented occurrence of giant garter snake in the Laguna Creek watershed, 9,521 acres of modeled upland habitat, 697 acres of modeled aquatic habitat, and 1,170 acres of high-value habitat.

The Laguna Creek watershed supports large acreages of modeled habitat for the covered mammals, including 47,492 acres of modeled general habitat for American badger and 45,883 acres of modeled foraging habitat for western red bat. The watershed supports about 4,946 acres of modeled roosting habitat for western red bat. The Laguna Creek watershed supports a moderate amount of modeled habitat for Sanford's arrowhead (12,535 acres, or 24% of the total in the Plan Area).

The Laguna Creek watershed also contains federally designated Critical Habitat for California tiger salamander (8,758 acres), Sacramento Orcutt grass (24,510 acres), and vernal pool fairy shrimp and vernal pool tadpole shrimp (27,048 acres).

3.2.3.7 Conservation Considerations

The large majority (88%) of the Laguna Creek watershed is located in PPU 7 outside UDA where limited Covered Activities would occur, but with substantial overlap with PPUs 6 and 8 in the western portion of the watershed. Chapter 7 of the SSHCP provides a detailed description of conservation considerations and conservation planning in these PPUs, with the main points summarized here.

The Laguna Creek watershed is one of the watersheds in the Plan Area least affected by man-made alterations and it supports numerous documented occurrences of Covered Species. In particular, it supports approximately 1,917 acres of the vernal pools in the Plan Area.

The conservation focus in the Laguna Creek watershed within PPUs 6 and 7 is maintaining large landscape Preserves that are interconnected, with valley grassland and vernal pool the primary conservation focus in PPU 7. In PPU 6, agricultural lands adjacent to the river and creek floodplains provide important foraging and roosting habitat for Covered Species such as Swainson's hawk, white-tailed kite, northern harrier, and greater sandhill crane.

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Under the SSHCP, 18,315 acres of existing conservation and 14,493 acres of planned conservation would occur in the Laguna Creek watershed, including total conservation of 25,960 acres of valley grassland and 2,192 acres of aquatic habitat (Table 13, Figure 10). Much of the conservation would occur in the eastern part of the watershed in association with the existing 12,500-acre Chance Ranch and planned conservation to build upon the existing conservation, creating a landscape Preserve totaling between 33,500 and 34,000 acres in the southeastern portion of the Plan Area, and including conservation in the Upper Cosumnes River to the north and Lower Dry Creek to the south.

Table 13
Summary of Conserved Land Cover Types in the Laguna Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Blue Oak Savanna	2,362	33	2,395
Blue Oak Woodland	987	—	987
Mine Tailing Riparian Woodland	1	63	64
Mixed Riparian Scrub	23	4	27
Mixed Riparian Woodland	46	6	52
Valley Grassland	13,146	12,814	25,960
<i>Terrestrial Total</i>	<i>16,565</i>	<i>12,920</i>	<i>29,485</i>
<i>Aquatic</i>			
Freshwater Marsh	40	19	59
Open Water	9	12	21
Seasonal Wetland	129	47	176
Streams/Creeks	106	60	166
Swale	132	164	296
Vernal Pool	953	580	1,533
<i>Aquatic Total</i>	<i>1,329</i>	<i>863</i>	<i>2,192</i>
<i>Agriculture</i>			
Cropland	194	140	334
Irrigated Pasture-Grassland	39	380	419
Orchards	—	2	2
Vineyards	120	17	137
<i>Agriculture Total</i>	<i>353</i>	<i>539</i>	<i>892</i>
<i>Non-Habitat Land Cover Type</i>			
Disturbed	8	—	8
High-density Development	6	—	6
Low-density Development	6	85	91
Major Roads	18	11	29
Mine Tailings	22	75	97

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Table 13
Summary of Conserved Land Cover Types in the Laguna Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
Recreation/Landscaped	8	—	8
<i>Non-Habitat Land Cover Type Total</i>	68	171	239
Grand Total	18,315	14,493	32,808

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

3.2.4 Lower Cosumnes River Watershed

3.2.4.1 Land Cover Types

The Lower Cosumnes River watershed is 46,683 acres, entirely located within the south-central portion of the Plan Area (Figure 2). This watershed consists primarily of Terrestrial and Agricultural land covers, accounting for 81% of the land covers in the watershed (Table 2, Figure 3). The terrestrial category is dominated by Valley Grasslands (14,593 acres), which accounts for approximately 87% of the total terrestrial land cover in the watershed. Agricultural areas total 21,153 acres and are the largest land covers in the Lower Cosumnes River watershed. Approximately 7% (3,514 acres) of the watershed is Aquatic land covers, including Seasonal Wetlands, Open Water, Freshwater Marsh, Vernal Pools, Wetland Restoration, Streams and Creeks and Swales. Approximately 11% (5,191 acres) of the watershed is Non-habitat land cover dominated by Low-Density Development (3,976 acres) and High-Density Development (667 acres). Impervious surfaces cover approximately 1,061 acres, or only 2%, of the watershed.

3.2.4.2 Hydrology

According to the NHD flowline dataset, the Lower Cosumnes River watershed consists primarily of stream/river (44%), canal/ditch (35%), and artificial path (22%) (Table 3, Figure 4). This watershed contains the lower portion of the Cosumnes River. The Cosumnes River and Badger Creek account for the majority of the stream/river and artificial path flowline data within this watershed. Agricultural areas are the largest land cover in this watershed, which is reflected by the high percentage of NHD flowline features categorized as canal/ditch.

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3.2.4.3 Geological Formations

Riverbank formations account for approximately 69% of the Lower Cosumnes River watershed (Table 4, Figure 5). Other important formations include basin deposits, laguna formation and levee and channel deposits.

3.2.4.4 Soils

Approximately 65% of the soils within the Lower Cosumnes River watershed are silt loams with the majority falling within the San Joaquin soil series (Table 5, Figure 6). The remaining soils are subcategories of loam (25%), clay (6%), water (1%), and other (2%).

3.2.4.5 Slope and Elevation

The entire watershed is on flat to gentle slopes (Table 6, Figure 7), with elevations ranging from 0-500 feet (Table 7, Figure 8).

3.2.4.6 Covered Species

The Lower Cosumnes River watershed includes documented occurrences for 19 of the 28 Covered Species, including dwarf downingia, legenere, Sanford's arrowhead, vernal pool fairy shrimp, mid-valley fairy shrimp, Ricksecker's water scavenger beetle, valley elderberry longhorn beetle, California tiger salamander, giant garter snake, western pond turtle, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, and white-tailed kite.

This watershed contains 15% of the Plan Area's known occurrences of Covered Species. The second largest number of sandhill crane occurrences (20%) are in Lower Cosumnes River watershed, as are relatively large percentages of occurrences for Cooper's hawk (35%), loggerhead shrike (62%), northern harrier (32%), Swainson's hawk (27%), and white-tailed kite (40%). Five of the 14 documented occurrences for giant garter snake are in this watershed, primarily in close proximity to the Cosumnes River and its tributaries. Although the Lower Cosumnes River watershed supports 619 acres of vernal pool, it has relatively few occurrences of the covered vernal pool plant and invertebrate species, including no occurrences for most of the plants. There are also no occurrences for western spadefoot or California tiger salamander in the watershed, and only two occurrences for western pond turtle.

The Lower Cosumnes River watershed contains variable amounts of modeled habitats for the covered vernal pool species, ranging from 1,269 acres for Ahart's dwarf rush to 6,210 acres for legenere (Table 9). However, with the exception of Boggs Lake hedge-hyssop, it contains

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substantially less modeled habitat for these species compared to the Laguna Creek (Section 3.2.3) and Morrison Creek (Section 3.2.7) watersheds. The Lower Cosumnes River watershed contains substantial acreages of modeled habitats for all of the covered bird species, including modeled foraging habitat ranging from about 19,420 acres for ferruginous hawk to 33,824 acres for tricolored blackbird and about 30,654 acres of modeled nesting/foraging habitat for burrowing owl. Second only to the Snodgrass Slough watershed (Section 3.2.9), the Lower Cosumnes River watershed supports the largest amount of high-value habitat for Swainson's hawk; 25,942 acres or 31% of the total in the Plan Area. The watershed supports variable amounts of modeled nesting habitat for covered birds, about 2,200 acres for the riparian/woodland nesting species (Cooper's hawk, Swainson's hawk, and white-tailed kite); about 30,654 acres for burrowing owl and 16,824 acres for loggerhead shrike; and about 28,950 acres for tricolored blackbird and 30,660 acres for northern harrier. The Lower Cosumnes River watershed also supports 369 acres of modeled roosting habitat for greater sandhill crane, second only to the Upper Cosumnes watershed, and 32% of the total modeled roosting habitat for the species in the Plan Area.

The Lower Cosumnes River watershed contains 90 of the 293 nest sites for Swainson's hawk, second only to the Snodgrass Slough watershed with 86 nest sites (Table 8). The watershed also contains by far the largest number of greater sandhill crane roost sites in the Plan Area (29 of the 48).

The watershed contains 7 of the 96 documented nest colonies for tricolored blackbird and 4 of 63 potential nest colonies. Approximately 2,980 individuals have been observed at the four nest colonies, or 2% of the approximately 158,330 individuals observed at nest colonies in the Plan Area over the different surveys. The four documented nest colonies have ranged in size from 130 to 1,500 individuals.

The Lower Cosumnes River watershed is important for all four of the covered amphibians and reptiles, and particularly giant garter snake. The watershed contains Badger Creek and other creeks that drain into the marsh at the Cosumnes River Preserve, which likely supports high-quality habitat due to its proximity and connectivity to a significant population of giant garter snake. The watershed supports 2,430 acres of modeled aquatic habitat, 8,934 acres of modeled upland habitat and 1,518 acres of high-value habitat for giant garter snake. The Lower Cosumnes River watershed also contains substantial modeled habitat for California tiger salamander, including more than 1,0700 acres of modeled aquatic habitat and almost 13,807 acres of modeled upland habitat. For western pond turtle, the watershed supports more than 1,866 acres of modeled breeding/foraging habitat (29% of the total in the Plan Area and second only to the Snodgrass Slough watershed). However, compared to some other watersheds, the Lower Cosumnes River watershed supports a modest amount of modeled nesting/aestivation habitat (11,195 acres, or 10% of the total). The western spadefoot has not been documented in the Lower Cosumnes River watershed, but the

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watershed supports substantial amounts of modeled habitat for the species, including almost 2,400 acres of modeled breeding habitat and about 14,590 acres of modeled aestivation habitat. The Lower Cosumnes River watershed supports substantial acreages of modeled habitat for the covered mammals, including more than 15,972 acres of modeled general habitat for American badger and almost 19,000 acres of modeled foraging habitat for western red bat. The watershed supports about 2,000 acres of modeled roosting habitat for western red bat. A bat monitoring program in the Cosumnes River Preserve has documented the occurrence of western red bat.

The Lower Cosumnes River watershed supports substantial modeled habitat for Sanford's arrowhead (9,713 acres, or 18% of the total in the Plan Area).

The Lower Cosumnes River watershed also contains federally designated Critical Habitat for Sacramento Orcutt grass (1,842 acres) and vernal pool fairy shrimp and vernal pool tadpole shrimp (2,069 acres).

3.2.4.7 Conservation Considerations

The large majority (96%) of the Lower Cosumnes River watershed is located outside of the UDA. The portions of the watershed that occur within the UDA also overlap with PPUs 4 and 8. The remaining portion of the watershed that is outside of the UDA encompasses approximately 4,941 acres of PPU 5, 31,008 acres of PPU 6, and 8,942 acres of PPU 7 (Table 11). Notably, PPU 6 contains much of the aquatic and riparian resources in the Plan Area. Compared to the other PPUs, PPU 6 is the most important PPU for covered bird species and giant garter snake.

Current existing hardline Preserve areas, all outside of the UDA, total 14,270 acres of the watershed, with almost all located in PPU 6 (Figure 10). They include the Stone Lakes National Wildlife Refuge and the Cosumnes River Preserve. Planned conservation totals 5,116 acres and includes agricultural and landscape Preserves as well as wetland and riparian restoration. These areas are immediately adjacent to existing Preserve areas and will focus on expanding the preservation of vernal pool habitat and important agricultural areas that provide foraging habitat for several covered bird species, including Swainson's hawk, white-tailed kite, tricolored blackbird, and greater sandhill crane, and roosting habitat for the crane. The Lower Cosumnes River watershed contains the second-most overall conservation in the Plan Area, with an emphasis on terrestrial and agricultural land covers (Table 14). In addition, approximately 2,340 acres of aquatic habitat will be conserved. Planned conservation will be located within PPUs 6 and 7 of the watershed.

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Table 14
Summary of Conserved Land Cover Types in the Lower Cosumnes River Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Mine Tailing Riparian Woodland	17	—	17
Mixed Riparian Scrub	168	53	221
Mixed Riparian Woodland	1,437	111	1,548
Valley Grassland	5,239	1,861	7,100
<i>Terrestrial Total</i>	6,861	2,025	8,886
<i>Aquatic</i>			
Freshwater Marsh	960	42	1,002
Open Water	218	11	229
Seasonal Wetland	417	49	466
Streams/Creeks	133	81	214
Swale	52	38	90
Vernal Pool	171	141	312
<i>Aquatic Total</i>	1,951	362	2,313
<i>Agriculture</i>			
Cropland	4,598	1,867	6,465
Irrigated Pasture-Grassland	365	587	952
Orchards	40	<1	40
Vineyards	386	158	544
<i>Agriculture Total</i>	5,389	2,612	8,001
<i>Non-Habitat Land Cover Type</i>			
Aqueducts	—	20	20
Low-Density Development	62	97	159
Major Roads	<1	<1	1
<i>Non-Habitat Land Cover Type Total</i>	62	117	179
Grand Total	14,263	5,116	19,379

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

3.2.5 Lower Dry Creek Watershed

3.2.5.1 Land Cover Types

The Lower Dry Creek watershed is located along the southern edge of the Plan Area (Figure 2). Approximately 33% of the watershed is located within the Plan Area. The watershed has very little non-agricultural development. Of the 18,493 acres in the watershed, approximately 5% are Terrestrial land covers and 38% are Agricultural land covers (Table 2, Figure 3).

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Valley Grasslands dominate the terrestrial land cover in the watershed, comprising 7,965 of the 10,359 acres mapped as Terrestrial. The large majority (93%) of agricultural areas are cropland and vineyards. Aquatic and Non-habitat land covers each comprise about 3% of the remaining acreage within the watershed. Impervious surfaces cover approximately 85 acres, or less than 1% of the watershed within the Plan Area.

3.2.5.2 Hydrology

Approximately 87% of the flowlines within the Lower Dry Creek watershed are streams and rivers (Table 3, Figure 4). Artificial path (about 6%), canal/ditch (7%), and connector (less than 1%) account for the remainder of the NHD flowline features in this watershed. This watershed encompasses Dry Creek, which is located along the southern boundary of the Plan Area. The watershed ends where Dry Creek terminates into Mokelumne River located to the west (Figure 2).

3.2.5.3 Geological Formations

The Lower Dry Creek watershed consists of several different geological formations with the combined Riverbank formations, Laguna and Mehrten Formations, totaling approximately 67% of the watershed (Table 4, Figure 5). Other formations include Valley Springs, alluvial deposit formations, and levee and channel deposits.

3.2.5.4 Soils

Approximately 91% of the watershed consists of fine sandy loam, gravelly loam, and sandy loam (Table 5, Figure 6). The remaining soils are subcategories of loam (6%), other (2%), clay (less than 1%), and water (less than 1%).

3.2.5.5 Slope and Elevation

The vast majority (99%) of the Lower Dry Creek watershed contains gentle slopes (i.e., 0-20% slopes) with a small fraction falling within the 20%–40% and >40% ranges (Table 6, Figure 7). Similarly, most of the watershed is within the 0–500 foot elevation range (Table 7, Figure 8). Only 40 acres (less than 1%), located along the eastern border of the Plan Area, is within the 500–1,000 foot elevation range.

3.2.5.6 Covered Species

The Lower Dry Creek watershed includes documented occurrences for 10 of the 28 Covered Species, including legenere, pincushion navarretia, vernal pool fairy shrimp, vernal pool tadpole

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shrimp, California tiger salamander, western spadefoot, northern harrier, greater sandhill crane, Swainson's hawk, and tricolored blackbird. Overall, the watershed only contains 5% of the Covered Species occurrences, but it does contain 33% of the pincushion navarretia occurrences (16 of 48) and 21% of the California tiger salamander occurrences (6 of 29).

Consistent with general lack of occurrences for most of the vernal pool Covered Species, the Lower Dry Creek watershed contains some of the least amount of modeled habitat for these species, ranging from only 327 acres for Ahart's dwarf rush acres to 7,131 acres for the vernal pool invertebrates (Table 9). Although the Lower Dry Creek watershed, at 18,493 acres in the Plan Area, is one of the smaller watersheds, it contains substantial acreages of modeled habitats for all of the covered bird species due to its large amount of natural land and agriculture, and lack of non-habitat cover types (Table 2, Figure 3). It supports more than 432 acres to about 12,000 acres (2%–65% of the total land cover) of modeled foraging habitat for Cooper's hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, white-tailed kite, and burrowing owl. The watershed supports variable amounts of modeled nesting habitat for covered birds, including 1,865 acres for Cooper's hawk and white-tailed kite, 448 acres for Swainson's hawk, 11,553 acres for burrowing owl, 8,413 acres for loggerhead shrike, 10,871 acres for tricolored blackbird (although no nesting colonies have been observed), and 11,023 acres for northern harrier. Nineteen of the 398 Swainson's hawk nest sites are in the watershed. The Lower Dry Creek watershed supports 1,942 acres of high-value foraging habitat for Swainson's hawk. The watershed supports relatively small amounts of modeled habitat for greater sandhill crane, including only 28 acres of roosting habitat and 3,289 acres of foraging habitat.

The Lower Dry Creek watershed is important for California tiger salamander, containing more than 9,911 acres of modeled aestivation habitat and 319 acres of modeled breeding/foraging habitat. As noted above, 6 of the 29 occurrences of California tiger salamander are in the Lower Dry Creek watershed. The watershed is less important for western spadefoot, western pond turtle, and giant garter snake. For western spadefoot, the Lower Dry Creek contains a relatively modest amount of modeled habitat compared to most of the other watersheds, including only 3% of the modeled breeding habitat and 6% of the modeled aestivation habitat in the Plan Area. Similarly, for western pond turtle, the watershed contains less modeled habitat than several of the other watersheds, including only 2% of the modeled breeding/foraging habitat and 7% of the modeled aestivation habitat in the Plan Area. The Lower Dry Creek watershed has low value for the giant garter snake, supporting no modeled aquatic habitat, and only 19 acres of modeled upland habitat.

The Lower Dry Creek watershed supports substantial acreages of modeled habitat for the covered mammals due to its undeveloped condition, including more than 8,879 acres of modeled general habitat for American badger, and about 8,531 acres of modeled foraging

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habitat for western red bat. The watershed also supports 2,559 acres of modeled roosting habitat for western red bat.

The Lower Dry Creek watershed supports a very small amount (773 acres) of modeled habitat for Sanford's arrowhead.

The Lower Dry Creek watershed also contains federally designated Critical Habitat for California tiger salamander (1,434 acres), Sacramento Orcutt grass (3,516 acres), and vernal pool fairy shrimp and vernal pool tadpole shrimp (4,335 acres).

3.2.5.7 Conservation Considerations

The Lower Dry Creek watershed is located primarily within southern portion of PPUPPU 7 (93%), with the remaining acreage located in PPUs 6 and 8. Almost the entire watershed is located outside of the UDA, except for the 1,099 acres in PPU 8 (Table 11). Because the majority of PPU 8 is located within Galt's city limits or sphere of influence it is anticipated that much of PPU 8 will eventually be urbanized.

Relative to some of the other watersheds, the Lower Dry Creek watershed has a lower priority for new conservation. Most of the species with modeled habitat in the watershed are broad ranging in the Plan Area and the conservation focus is elsewhere. Even for the more limited California tiger salamander, the conservation focus is in the Laguna Creek watershed, which contains 79% of the occurrences and large majority of modeled habitats for the species (Table 9). Further, other than expected build-out in PPU 8, the Covered Activities will have small impacts in the Lower Dry Creek watershed. The large majority (96%) of conservation in Lower Dry Creek Watershed is in existing conservation (8,652 acres), located primarily within PPU 7, and mostly in Chance Ranch (Tables 15 and 11). A small amount of planned conservation, primarily agriculture, is also proposed in the watershed. The majority of total conservation will be concentrated on terrestrial habitats, with emphasis on blue oak woodland and valley grassland and will be located within PPU 8.

Table 15
Summary of Conserved Land Cover Types in the Lower Dry Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Blue Oak Savanna	529	—	529
Blue Oak Woodland	1,406	—	1,406
Mixed Riparian Scrub	3	—	3
Mixed Riparian Woodland	79	—	79

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Table 15
Summary of Conserved Land Cover Types in the Lower Dry Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
Valley Grassland	5,717	188	5,905
<i>Terrestrial Total</i>	7,734	188	7,922
<i>Aquatic</i>			
Freshwater Marsh	4	—	4
Open Water	4	—	4
Seasonal Wetland	67	4	71
Streams/Creeks	29	<1	29
Swale	50	2	52
Vernal Pool	155	3	158
<i>Aquatic Total</i>	309	9	318
<i>Agriculture</i>			
Cropland	72	152	224
Irrigated Pasture-Grassland	285	7	292
Vineyards	251	<1	251
<i>Agriculture Total</i>	608	159	767
<i>Non-Habitat Land Cover Type</i>			
High-Density Development	1	—	1
<i>Non-Habitat Land Cover Type Total</i>	1	—	1
Grand Total	8,652	356	9,008

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

3.2.6 Lower Mokelumne River Watershed

3.2.6.1 Land Cover Types

Although the Lower Mokelumne River watershed is more than 141,965 acres in size, only 3% of the watershed is located in the far southwest corner of the southern Plan Area (Figure 2) and it accounts for only 1% of the Plan Area. Due its minor role in the Plan Area, the discussion in this section is somewhat abbreviated compared to the discussions for the other watersheds. The small portion of this watershed located within the Plan Area is primarily made up of Agricultural land covers, specifically croplands. The remaining acreage includes Mixed Riparian Scrub and Woodland, and Aquatic land covers, and some residential areas. Impervious surfaces cover approximately 29 acres, or 1% of the watershed within the Plan Area.

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3.2.6.2 Hydrology

The portion of the Lower Mokelumne River watershed that occurs within the Plan Area contains only artificial path and canal/ditch NHD flowline features (Table 3, Figure 4). The Mokelumne River, represented by the artificial path features, serves as a portion of the southern border for the Plan Area. This watershed extends to the west as a long sliver surrounding the Mokelumne River. The watershed ends where Lower Dry Creek terminates into the river. The canal and ditch flowline features, which account for 88% of the watershed, cross through the agricultural land covers, providing water to the area.

3.2.6.3 Geological Formations

Geological information is only available for the eastern sliver of the Lower Mokelumne River watershed. This portion of the watershed is dominated by intertidal deposits (53%), with basin deposits and levee and channel deposits accounting for the rest of the watershed (Table 4, Figure 5).

3.2.6.4 Soils

The majority (59%) of the Lower Mokelumne River watershed consists of clay soils, specifically Egbert clay, partially drained, 0 to 2% slopes (Table 5, Figure 6). The remaining soils are loam subcategories (35%) and water (5%).

3.2.5.5 Slope and Elevation

The entire watershed is on flat to gentle slopes with elevations ranging from 0 to 500 feet (Tables 6 and 7, Figures 8 and 9).

3.2.6.6 Covered Species

The Lower Mokelumne River watershed only contains three documented occurrences of one Covered Species: Sanford's arrowhead. This species is located on the boundary of the Plan Area within the Mokelumne River. Similar to the Lower Dry Creek watershed, the lack of occurrences of Covered Species within this watershed may be attributed to large amounts of land that have been converted for agricultural purposes. In addition, only a very small portion of the watershed is actually located within the Plan Area.

Due to its small size within the Plan Area, the Lower Mokelumne watershed includes less than 1% of the modeled habitat for Covered Species. The watershed does not contain any modeled habitat for vernal pool species and contains limited habitat for giant garter snake, western pond turtle, and western spadefoot, none of which is high-value giant garter snake habitat. Of the

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2,019 acres of this watershed within the Plan Area, anywhere from 9 to 1,700 acres are modeled habitat for several of the covered bird species, including burrowing owl, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, and white-tailed kite. All of the modeled habitat for Swainson's hawk (1,878 acres) is considered high value. There is limited habitat for Cooper's hawk (200 acres) and ferruginous hawk (9 acres). Approximately 200 acres of modeled roosting habitat for western red bat are present in the watershed. There are 94 acres of modeled foraging habitat for western red bat. Only a small amount of modeled habitat for Sanford's arrowhead (13 acres) is in the watershed.

3.2.6.7 Conservation Considerations

The entire Lower Mokelumne River watershed is located outside of the UDA within PPU 6. Approximately 1,640 acres of the 2,019 acres located within the Plan Area contain existing hardline Preserve areas (Table 16, Figure 10). Due to its small size within the Plan Area and general lack of resources for the Covered Species relative to several of the other watersheds, no new conservation is proposed under the SSHCP.

Table 16
Summary of Conserved Land Cover Types in the Lower Mokelumne River Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Mixed Riparian Scrub	1	—	1
Mixed Riparian Woodland	149	—	149
<i>Terrestrial Total</i>	150	—	150
<i>Aquatic</i>			
Freshwater Marsh	21	—	21
Open Water	3	—	3
Streams/Creeks	<1	—	<1
<i>Aquatic Total</i>	24	—	24
<i>Agriculture</i>			
Cropland	1,464	—	1,464
Vineyards	<1	—	<1
<i>Agriculture Total</i>	1,464	—	1,464
<i>Non-Habitat Land Cover Type</i>			
Low-density Development	4	—	4
<i>Non-Habitat Land Cover Type Total</i>	4	—	4
Grand Total	1,642	—	1,642

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

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3.2.7 Morrison Creek Watershed

3.2.7.1 Land Cover Types

The Morrison Creek watershed is located within the northern half of the Plan Area (Figure 2). Of the 69,540 acres that comprise this watershed, 62%, or 42,926 acres, are located within the Plan Area, almost entirely inside the UDA (Table 11). Because it is located in the urbanizing portion of Sacramento County, approximately 45% of the watershed has already been developed and contains Non-habitat land covers, primarily High-Density Development. Agriculture accounts for about 10% of the watershed. Terrestrial (51%) and Aquatic (5%) land covers account for the remaining land covers in the Morrison Creek watershed. Valley Grassland accounts for about 98% of the Terrestrial land cover. This watershed also supports all of the aquatic cover types, including approximately 764 acres of Vernal Pools, 359 acres of Swale, and 107 acres of Seasonal Wetlands, which are embedded in the Valley Grasslands. Laguna Creek (north) is a significant east–west landscape feature that plays a prominent role in conservation. Impervious surfaces cover approximately 6,771 acres, or 16%, of the watershed. Along with the American River (51% impervious surfaces) and Sherman Lake-Sacramento River (24% impervious surfaces) watersheds, the Morrison Creek watershed has one of the three highest percentages of impervious surfaces in the Plan Area. Reflecting both its large size and more urbanized character, it also has by far the highest amount of impervious surface acreage in the Plan Area, with Snodgrass Slough having the second highest amount at approximately 1,124 acres.

3.2.7.2 Hydrology

The Morrison Creek watershed contains approximately 9% of the Plan Area’s NHD flowline features (Table 3, Figure 4). Approximately 83% of the flowline features are stream and river features including Morrison Creek, Laguna Creek (north), Elder Creek, Strawberry Creek, Unionhouse (Beacon) Creek, and Frye Creek. Folsom South Canal accounts for the majority of the 72,483 linear feet of artificial path features. Canal/ditch features make up approximately 6% of the NHD flowline features within the Plan Area with connectors (1%) and pipeline (less than 1%) rounding out the remaining areas.

3.2.7.3 Geological Formations

The laguna and riverbank formations comprise 97% of the acreage in the Morrison Creek watershed (Table 4, Figure 5). The remaining prominent formations in the watershed include basin deposits and mine and dredge tailings.

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3.2.7.4 Soils

The Morrison Creek watershed primarily contains loam subcategories such as silt loam, loam, and gravelly loam, which account for about 84% of the watershed (Table 5). Approximately 50% of the loam soils are from the San Joaquin soil series. Other loam subcategories comprise 4% of the soils, water covers less than 1% of the watershed, and 7% of the soils are listed in the Other category. Approximately 3% of the Other category is related to mining activities (dumps, pits, slickens, and Xerorthents, dredge tailings, 2% to 50% slopes) or urban development.

3.2.7.5 Slope and Elevation

The majority of the watershed is on flat to gentle slopes with elevations ranging from 0–500 feet (Table 6, Figure 7). Only 2 acres of the watershed are within the 20%–40% slope range (Table 7, Figure 8).

3.2.7.6 Covered Species

The Morrison Creek watershed includes documented occurrences for 23 of the 28 Covered Species despite substantial urbanization (Table 8). Covered species documented in the watershed include Ahart's dwarf rush, Boggs Lake hedge-hyssop, legenere, Sacramento Orcutt grass, slender Orcutt grass, Sanford's arrowhead, vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, western spadefoot, giant garter snake, western pond turtle, American badger, and western red bat.

This watershed has the third highest percentage (16%) of known occurrences for Covered Species in the Plan Area, including 43% of the covered vernal pool plants and 53% of the vernal pool invertebrate occurrences (Table 8). Due to the large area of vernal pools (764 acres and second only to the Laguna Creek watershed), swale, and seasonal wetlands, vernal pool flora and fauna are the most important biological resources in the watershed. The majority of most covered vernal pool plant occurrences in the Plan Area are in the Morrison Creek watershed, including both occurrences of Ahart's dwarf rush, all 4 occurrences of slender Orcutt grass, 27 of 30 occurrences of Boggs Lake hedge-hyssop, and 30 of 56 occurrences of legenere. The watershed also includes 12 of 63 occurrences for Sacramento Orcutt grass (with all but 2 of the remaining occurrences in the Deer Creek watershed). Similarly, the vernal pool invertebrates are well-represented in the Morrison Creek watershed, including 505 of the 748 occurrences of vernal pool tadpole shrimp, 196 of the 572 occurrences of vernal pool fairy shrimp, and 18 of 33 occurrences of mid-valley fairy shrimp. Western spadefoot, which is strongly associated with vernal pools and other ephemeral wetlands, has also been frequently found in the Morrison

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Creek watershed, with 9 of the 31 occurrences in the Plan Area. The large majority of occurrences for these vernal pool species outside the Morrison Creek watershed are from the Laguna Creek watershed (Section 3.2.3). Although not a vernal pool species, 12 of the 63 occurrences of Sanford's arrowhead are from the watershed.

The Morrison Creek watershed, which includes Laguna Creek (north) and several other prominent creeks, includes 1 of 14 occurrences of giant garter snake (2 of 18 occurrences of western pond turtle

While there are occurrence data for all of the avian Covered Species in the Morrison Creek watershed, with a range of 1% of the occurrences for greater sandhill crane to 31% of the occurrences for Cooper's hawk, none stand out as prominent in the watershed. Also, except for species such as Swainson's hawk, tricolored blackbird, and sandhill crane (see discussion below), the occurrence data for avian species are not comprehensive for the Plan Area. Similarly, there are little data for the mammals in the Plan Area, with occurrence records for American badger (7 of 8 occurrences in the Plan Area) and western red bat (2 of 7 occurrences in the Plan Area).

Due to its large size and large number of land cover types, of the 10 watersheds in the Plan Area, the Morrison Creek watershed contains among the largest acreages of modeled habitat for most Covered Species (Table 9).

Consistent with the occurrence of all the vernal pool Covered Species, the Morrison Creek watershed contains substantial modeled habitat for these species, ranging from 2,200 acres for dwarf downingia to 18,400 acres for the vernal pool fairy shrimp and vernal pool tadpole shrimp (Table 9).

The Morrison Creek watershed contains substantial acreages of modeled habitat for all of the covered bird species, including up to 26,000 acres of modeled foraging habitat for Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, and white-tailed kite; about 1,593 acres of modeled foraging habitat for greater sandhill crane (but only 17 acres of modeled roosting habitat); and almost 24,956 acres of modeled nesting/foraging habitat for burrowing owl. The watershed also supports large amounts of modeled nesting habitat for covered birds that can use a variety or more broad-scale land cover types for nesting (e.g., valley grassland), including loggerhead shrike (21,781 acres), northern harrier (24,938 acres), and tricolored blackbird (24,016 acres). However, for covered birds that are limited to riparian and woodland habitats for nesting, the Morrison Creek watershed supports modest amounts of modeled nesting habitat relative to its large size, including 487 acres for Cooper's hawk, 487 acres for white-tailed kite, and 358 acres for Swainson's hawk.

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The Morrison Creek watershed contains 11 of the 293 Swainson's hawk nest sites and supports 1,926 acres of high-value foraging habitat for the species.

Along with the Laguna Creek watershed, the Morrison Creek watershed supports the largest number of documented and potential tricolored blackbird nest colonies in the Plan Area, with 42 of the 96 documented nest colonies and 16 of 63 potential nest colonies. The 42 documented nest colonies have ranged in size from approximately 100 individuals to 7,500 individuals in 1994. Approximately 50,690 individuals have been observed at the nest colonies over the course of the surveys, or 32% of the approximately 158,330 individuals observed at nest colonies in the Plan Area.

As noted above, the Morrison Creek watershed contains several occurrences of western spadefoot, western pond turtle, and giant garter snake, and it also provides substantial modeled habitat for these species. For western spadefoot, vernal pool, swale, and seasonal wetland are primary breeding habitats, and contribute to about 2,240 acres of modeled breeding habitat for the species in the watershed. For western pond turtle, the Morrison Creek watershed supports 515 acres of modeled breeding/foraging habitat and 8,750 acres of modeled nesting/aestivation habitat. The Laguna Creek Wildlife Corridor is an important habitat feature for western pond turtle because it provides important in-stream habitat to support breeding, foraging, movement, and dispersal. The western portion of the Morrison Creek watershed has important value for giant garter snake, but is not as critical for this species compared to the Lower Cosumnes River (Section 3.2.4) and Snodgrass Slough (Section 3.2.9) watersheds. The Morrison Creek watershed contains 3,258 acres of modeled upland habitat, 441 acres of modeled aquatic habitat, and 1,388 acres of high-value habitat for giant garter snake.

The Morrison Creek watershed supports large acreages of modeled habitat for covered mammals, including approximately 22,542 acres of modeled general habitat for American badger and more than 23,376 acres of modeled foraging habitat for western red bat. The watershed supports a limited amount of roosting habitat for western red bat, including about 504 acres .

The Morrison Creek watershed also contains federally designated Critical Habitat for Sacramento and slender Orcutt grass (1,161 acres) and vernal pool fairy shrimp and vernal pool tadpole shrimp (2,451 acres).

3.2.7.7 Conservation Considerations

About 45% of the Morrison Creek watershed within the Plan Area (99% of which is inside the UDA) is already developed and has little or no habitat value for the Covered Species. For this reason, approximately 23% of the watershed is outside of the PPU's (Table 11), although the Laguna Creek Wildlife Corridor outside the PPU's is an important habitat feature in the

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watershed. However, as discussed in Section 3.2.7.6, the Morrison Creek watershed supports almost all of the Covered Species in the Plan Area and, along with the Laguna Creek watershed, is critical for conservation of the vernal pool ecosystems and associated plant and animal species in the Plan Area. The MCRA is an important component of the conservation of these resources in the watershed. Therefore, despite anticipated urban build out of much of the watershed inside the UDA, protection of these remaining resources in the watershed is one of the most important elements of the SSHCP and ARP conservation strategies.

Substantial conservation has already occurred in the Morrison Creek watershed in PPU's 1, 2, and 3, with existing conservation in the watershed totaling approximately 2,888 acres of hardline Preserve areas (Table 17). The SSHCP will add approximately 6,220 acres to existing conserved areas through designation of core, minor, and satellite Preserves and linkage Preserves inside the UDA, almost doubling the amount of conservation. The majority of planned conservation will be focused on valley grasslands (5,885 acres), and vernal pool and swale that occur within the valley grasslands, comprising the vernal pool ecosystem. One of the objectives of the SSHCP is to protect an additional 1,200 acres along the Laguna Creek Wildlife Corridor, which will provide both resident and movement habitat for many of the covered wildlife species, including western pond turtle and giant garter snake (see Chapter 7 of the SSHCP).

Table 17
Summary of Conserved Land Cover Types in the Morrison Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Blue Oak Savanna	—	15	15
Mine Tailing Riparian Woodland	—	1	1
Mixed Riparian Scrub	3	19	22
Mixed Riparian Woodland	1	75	76
Valley Grassland	2,456	4,740	7,196
<i>Terrestrial Total</i>	<i>2,460</i>	<i>4,850</i>	<i>7,310</i>
<i>Aquatic</i>			
Streams/Creeks (VPIH)	9	22	31
Freshwater Marsh	12	227	239
Open Water	4	67	71
Seasonal Wetland	1	35	36
Streams/Creeks	20	23	43
Swale	73	80	153
Vernal Pool	207	197	404
<i>Aquatic Total</i>	<i>326</i>	<i>651</i>	<i>977</i>

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Table 17
Summary of Conserved Land Cover Types in the Morrison Creek Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Agriculture</i>			
Cropland	—	244	244
Irrigated Pasture-Grassland	22	58	80
Orchards	—	18	18
<i>Agriculture Total</i>	22	320	342
<i>Non-Habitat Land Cover Type</i>			
Disturbed	3	6	9
High-Density Development	45	<1	45
Low-Density Development	6	39	45
Major Roads	2	2	4
Mine Tailings	—	1	1
Recreation/Landscaped	24	16	40
<i>Non-Habitat Land Cover Type Total</i>	80	64	144
Grand Total	2,888	5,885	8,773

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

3.2.8 Sherman Lake-Sacramento River Watershed

3.2.8.1 Land Cover Types

The Sherman Lake-Sacramento River watershed is located in the extreme western portion of the Plan Area, with approximately 12% located within the Plan Area (Table 1, Figure 2). The watershed intersects the Plan Area in four separate locations that together comprise about 5% of the Plan Area, including a large area along the northern portion of the Plan Area, a small area in the northwest corner of the Plan Area, and two areas along the western portion of the Plan Area. The Sherman Lake-Sacramento River watershed in the Plan Area is dominated by human activities. Together, Non-habitat and Agricultural land cover types account for 88% of the land covers in the watershed (Table 2, Figure 3). Of these two land cover types, High-Density Development and Cropland contain the largest acreages at 3,049 and 4,986 acres, respectively, accounting for 57% of the total land covers in the watershed within the Plan Area. The Sherman Lake-Sacramento River watershed contains all of the Aquatic land cover types mapped within the Plan Area, but in small amounts ranging from 1 to 40 acres and totaling only 79 acres. Terrestrial land covers, primarily Valley Grassland, comprise the remaining acreage, but only totaling 848 acres, or 6% of the land cover in the watershed within the Plan Area. Impervious

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surfaces cover approximately 3,370 acres, or 24%, of the watershed, which is the highest percentage of the watersheds in the Plan Area.

3.2.8.2 Hydrology

According to the NHD flowline dataset, the majority of the hydrologic features within this watershed are canal/ditch (70%) (Table 3, Figure 4). The high percentage of canal/ditch features mapped within the Sherman Lake-Sacramento River watershed is related to the large amount of agricultural land covers mapped in the watershed. Artificial path features account for 27% of the watershed, stream/river features total 3%, and the remaining 0.1% of the watershed consists of pipeline connector features. The Sacramento River and the Folsom Canal encompass the artificial path features mapped within this watershed.

3.2.8.3 Geological Formations

Geological formation data is only available for a little less than half of the Sherman Lake-Sacramento River watershed. Intertidal and levee and channel deposits dominate this watershed, with basin deposits making up most of the rest of the watershed (Table 4, Figure 5).

3.2.8.4 Soils

The majority of the soils located in this watershed are loam subcategories (45%) and clay (12%) (Table 5, Figure 6). The remaining areas contain water (5%), mucky clay (26%) or are listed under the Other category (12%). The majority of the Other category is related to mining activities (dumps, pits, slickens, and Xerorthents, dredge tailings) or urban development.

3.2.8.5 Slope and Elevation

The entire watershed is on flat to gentle slopes with elevations ranging from 0–500 feet (Tables 6 and 7, Figures 8 and 9).

3.2.8.6 Covered Species

The Sherman Lake-Sacramento River watershed includes documented occurrences for 10 of the 28 Covered Species, including Sanford's arrowhead, vernal pool fairy shrimp, burrowing owl, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, and western red bat (Table 8). Overall, the watershed accounts for accounts for 27% of the Covered Species occurrences in the Plan Area, most of which are sandhill crane occurrences. The large majority (88%) of the Sherman Lake-Sacramento River watershed is developed or agriculture, which accounts for the relatively small number of Covered Species with occurrences

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in the watershed compared to several of the other watersheds. Also, several of the species occurrences are located in non-habitat land covers and may no longer be extant. Almost all of the covered bird species documented in the Sherman Lake-Sacramento River watershed forage in croplands (4,986 acres in the watershed) and western red bat roosts in orchards.

Consistent with the lack of occurrence records for most Covered Species, the Sherman Lake-Sacramento River watershed lacks substantial modeled habitat for most of the Covered Species. For the covered vernal pool plant and animals, modeled habitat ranges from 7 acres for pincushion navarretia to 326 acres for the vernal pool invertebrates. Likewise, for the amphibians and reptiles, modeled habitat ranges from no habitat for California tiger salamander (the watershed is outside its range in the Plan Area) to about 627 acres of modeled upland habitat for western spadefoot. The occurrence of these species in the watershed is limited by a lack of modeled aquatic habitat, including only 66 acres for giant garter snake, 7 acres for western pond turtle, and 23 acres for western spadefoot.

The croplands and valley grassland (665 acres) in the Sherman Lake-Sacramento River watershed does provide habitat for several of the covered birds. The watershed supports anywhere from 14 to 1,711 acres of modeled foraging habitat for loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, and white-tailed kite, and this habitat also is modeled nesting habitat for northern harrier and tricolored blackbird. Notably, 1,356 acres of the modeled foraging habitat for Swainson's hawk is high-value habitat. The watershed provides about 1,704 acres of modeled nesting/foraging habitat for burrowing owl and about 855 acres of modeled foraging habitat for greater sandhill crane (but no modeled roosting habitat). The watershed contains limited habitat for the covered birds that nest in riparian and woodland habitat—182 acres for Cooper's hawk, Swainson's hawk (only 3 of the 295 nest sites), and white-tailed kite. The watershed contains 3 of the 96 documented nest colonies for tricolored blackbird and no potential nest colonies. While 2 of the 3 documented nest colonies are small, about 100 and 200 birds each, approximately 9,000 individuals were observed at the third site in 1944, making it the largest documented nest colony in the Plan Area.

The watershed contains almost 787 acres of modeled foraging habitat and almost 1,540 acres of modeled roosting habitat for western red bat. The watershed contains 633 acres of modeled habitat for American badger, but with the high level of urban development and intensive agriculture in the watershed, this species is unlikely to occur.

The Sherman Lake-Sacramento River watershed contains only 41 acres of modeled habitat for Sanford's arrowhead.

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3.2.8.7 Conservation Considerations

Seventy percent of the Sherman Lake-Sacramento River watershed is located outside of the UDA in PPU 6 (Table 11). The remainder of the watershed overlaps with PPUs 1, 2, and a very small portion (25 acres) of PPU 4, with the rest outside of any PPUs. The Sherman Lake-Sacramento River watershed within the Plan Area has 757 acres of existing conservation, all of which is located in PPU 4 (Table 18, Figure 10). However, the croplands in the watershed are important foraging habitat for several of the covered bird species, including Swainson's hawk (5,630 acres of high-value habitat), loggerhead shrike, northern harrier, greater sandhill crane, tricolored blackbird, and white-tailed kite. Accordingly, the SSHCP protects approximately 3,590 acres of agricultural Preserve within the watershed, or approximately 31% of the total planned agricultural Preserve in the Plan Area. All of the planned conservation will be located within PPU 6.

Table 18
Summary of Conserved Land Cover Types in the
Sherman Lakes-Sacramento River Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Mixed Riparian Scrub	—	—	0
Mixed Riparian Woodland	—	<1	<1
Valley Grassland	—	1	1
<i>Terrestrial Total</i>	0	1	1
<i>Aquatic</i>			
Freshwater Marsh	—	—	0
Streams/Creeks	<1	—	<1
<i>Aquatic Total</i>	<1	0	<1
<i>Agriculture</i>			
Cropland	753	101	854
Orchards	—	—	0
Vineyards	—	—	0
<i>Agriculture Total</i>	753	101	854
<i>Non-Habitat Land Cover Type</i>			
Disturbed	2	—	2
Low-density Development	1	<1	1
Major Roads	1	—	1
<i>Non-Habitat Land Cover Type Total</i>	4	<1	4
Grand Total	757	102	859

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

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3.2.9 Snodgrass Slough Watershed

3.2.9.1 Land Cover Types

Snodgrass Slough is the fifth largest watershed in the Plan Area behind the Laguna Creek Lower Cosumnes, Deer Creek and Morrison Creek watersheds and is entirely contained within the western portion of the Plan Area (Table 1, Figure 2). About 64% of the watershed is Agriculture, of which, about 63% is Croplands; Croplands cover about 40% of the entire watershed. Non-habitat land cover types, dominated by Low-Density Development, account for 7% of the watershed. Terrestrial habitat, dominated by Valley Grassland (76%), Mixed Riparian scrub and Woodland, covers about 19% of the watershed. The Snodgrass Slough watershed accounts for the highest acreage of Aquatic land cover within the Plan Area. Approximately 4,104 acres of the watershed supports all of the aquatic cover types mapped within the Plan Area, and represents 25% of the aquatic habitat in the Plan Area. Impervious surfaces cover approximately 1,124 acres, or 3%, of the watershed.

3.2.9.2 Hydrology

Reflecting the dominance of agricultural land covers within the watershed, approximately 72% of the NHD flowlines in the Snodgrass Slough are canal/ditch features (Table 3, Figure 4). Artificial paths account for almost 21% of the watershed while stream/river features comprise 7% and connector features are less than 1% of the watershed.

3.2.9.3 Geological Formations

Geological formation data are available for approximately 60% of the Snodgrass Slough watershed. Almost the entire watershed consists of riverbank formations, which make up approximately 72% of the watershed (Table 4, Figure 5). The remaining 1% of mapped geological data for the watershed consists of basin, intertidal and levee and channel deposits.

3.2.9.4 Soils

The majority of the soils in the Snodgrass Slough watershed are subcategories of loam soils (60%) (Table 5, Figure 6). The largest acreage falls into the silt loam category (32%), most of which contains the San Joaquin soil series. Approximately 32% of the watershed contains clay soils with water (4%) and the Other (1%) category rounds out the remaining acreage.

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3.2.9.5 Slope and Elevation

The entire watershed is on flat to gentle slopes with elevations ranging from 0–500 feet (Tables 6 and 7, Figures 8 and 9).

3.2.9.6 Covered Species

The Snodgrass Slough watershed includes documented occurrences for 18 of the 28 Covered Species, including dwarf downingia, legenere, Sanford's arrowhead, vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, giant garter snake, western pond turtle, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, and American badger, (Table 8). This watershed contains 17% of known occurrences for Covered Species in the Plan Area, fourth only to the Laguna Creek (26%) watershed, Sherman Lake-Sacramento River (20%) and Morrison Creek watersheds (16%). While the watershed contains occurrences for only two of the covered vernal pool plant species, it has the highest number of occurrences of dwarf downingia (7 of the 10 occurrences in the Plan Area) and second highest number of occurrences of legenere (12 of the 56 occurrences in the Plan Area). The watershed contains a small percentage of the occurrences in the Plan Area for vernal pool fairy shrimp (3%) and vernal pool tadpole shrimp (3%), but does contain 27% (9 of 33 occurrences) for mid-valley fairy shrimp. As an aquatic plant species, Sanford's arrowhead is well represented in the Snodgrass Slough watershed, with 56% of the occurrences (35 of 63) in the Plan Area.

The Snodgrass Slough watershed is important for both giant garter snake and western pond turtle. It supports an important subpopulation of giant garter snake, with 7 of the 14 occurrences in the Plan Area and 5 of the 18 occurrences for western pond turtle. Reflecting the more perennial and intermittent nature of the aquatic habitats (about 70% of the aquatic habitats are freshwater marsh, stream/creek, and open water), there are no documented occurrences for western spadefoot in the watershed. Also, the watershed is outside the range of California tiger salamander.

There are occurrence data for all of the avian Covered Species in the Snodgrass Slough watershed, including 32% of the occurrences for Swainson's hawk (127 of the 398 occurrences). Occurrence data for the other species ranges from 2% of the Plan Area occurrences of tricolored blackbird to 22% of the occurrences for greater sandhill crane (see discussion below).

Of the covered mammals, one of the eight occurrences for American badger are in the Snodgrass Slough watershed.

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Due to its large size and large number and dominance by agriculture, of the 10 watersheds in the Plan Area, the Snodgrass Slough watershed contains among the largest acreages of modeled habitat for the Covered Species that use agriculture (Table 9).

For plants, the Snodgrass Slough contains over 1,679 acres of modeled habitat for legumens and over 2,817 acres of modeled habitat for Sanford's arrowhead. The watershed contains 1,918 acres of modeled habitat for the vernal pool invertebrates.

As an important area for giant garter snake and western pond turtle, the Snodgrass Slough contains large amounts of modeled habitat for both species. For giant garter snake, the watershed supports 3,559 acres of modeled aquatic habitat, 5,760 acres of modeled upland habitat and 6,350 acres of high-value habitat. The Snodgrass Slough and Lower Cosumnes River (Section 3.2.4) combined support 92% of the high-value habitat for giant garter snake. The Snodgrass Slough watershed also contains the largest amount of modeled breeding/foraging habitat for western pond turtle of the 10 watersheds in the Plan Area (2,005 acres, or 32% of the total in the Plan Area), and also contains almost 6,517 acres of nesting/aestivation habitat. Although western spadefoot has not been documented in the Snodgrass Slough watershed, the watershed supports 2,987 acres of modeled aquatic habitat and 5,945 acres of modeled upland.

The Snodgrass Slough watershed contains substantial acreages of modeled habitats for all of the covered bird species, including approximately 2,243 to 26,700 acres of modeled foraging habitat for loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, and white-tailed kite; about 10,452 acres for ferruginous hawk; and about 25,499 acres of modeled nesting/foraging habitat for burrowing owl.

The watershed also supports large amounts of modeled nesting habitat for covered birds that can use a variety or more broad-scale land cover types for nesting (e.g., cropland, irrigated pasture-grassland, and valley grassland), including burrowing owl (25,499), northern harrier (28,260 acres), and tricolored blackbird (24,016 acres). Although the watershed supports substantial modeled nesting habitat for tricolored blackbird, only 1 of the 96 documented nest colonies and 2 of 63 potential nest colonies are in the watershed; about 100 individuals were observed at the documented nest colony in 1992. The watershed also contains more than 421 acres of modeled roosting habitat for greater sandhill crane, which accounts for 36% of the total in the Plan Area; modeled roosting habitat in the Snodgrass Slough and Lower Cosumnes River watersheds account for 99% of the total modeled roosting habitat in the Plan Area. Much of the high-value habitat (33%) for greater sandhill crane occurs in Snodgrass Slough. Twelve of the 48 documented roosting sites for greater sandhill crane in the Plan Area are in this watershed. For covered birds that are limited to riparian and woodland habitats for nesting, the Snodgrass Slough watershed supports modest amounts modeled nesting habitat relative to its large size—

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1,767 acres for Cooper's hawk, Swainson's hawk, and white-tailed kite. However, despite a limited amount of modeled nesting habitat, the watershed has the highest proportion (38%) of Swainson's hawk nest sites of the watersheds in the Plan Area. Further, reflecting the value of agriculture as foraging habitat for Swainson's hawk, the watershed includes 28,340 acres of high-value foraging habitat for the species.

The Snodgrass Slough watershed supports more than 10,508 acres of foraging habitat and 1,874 acres of modeled roosting habitat for western red bat, including. The watershed also supports about 7,158 acres of modeled general habitat for American badger.

3.2.9.7 Conservation Considerations

The majority of the Snodgrass Slough watershed (98%) is located outside of the UDA within PPU 6 (Table 11). The remaining 1,006 acres of the watershed intersect PPU 4 PPU. PPU 4 encompasses the proposed sphere of influence for the City of Elk Grove. Because much of PPU 4 is located in the city's proposed sphere of influence and in the county's Urban Services Boundary (USB), it is anticipated that much of PPU 4 will eventually be urbanized.

The primary conservation considerations for the Snodgrass Slough watershed are giant garter snake and western pond turtle (to a lesser extent) and the covered birds. The watershed supports large percentages of high-value habitat in the Plan Area for giant garter snake and Swainson's hawk. For giant garter snake, the 6,030 acres of high-value habitat is 45% of the total in the Plan Area and for Swainson's hawk, the 31,230 acres of high-value habitat is 37% of the total in the Plan Area.

Existing conservation totals about 8,944 acres (62%) of the watershed and an additional 5,497 acres are planned for conservation (Table 19, Figure 10). A large portion of the planned conservation will include agricultural Preserves (82%) with the remaining acreage set aside for wetland restoration. The agricultural Preserves will provide high-value foraging habitat for Swainson's hawk, as well as many of the other Covered Species that use agricultural habitats. All of the planned conservation will occur within PPU 6. The Snodgrass Slough watershed will contain the highest acreage of total conservation for aquatic and agricultural land covers in the Plan Area.

Table 19
Summary of Conserved Land Cover Types in the Snodgrass Slough Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Mixed Riparian Scrub	232	41	273
Mixed Riparian Woodland	246	67	313

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Table 19
Summary of Conserved Land Cover Types in the Snodgrass Slough Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
Valley Grassland	3,425	93	3,518
<i>Terrestrial Total</i>	3,903	201	4,104
<i>Aquatic</i>			
Freshwater Marsh	705	48	753
Open Water	465	26	491
Seasonal Wetland	655	24	679
Streams/Creeks	206	45	251
Swale	2	—	2
Vernal Pool	290	2	292
<i>Aquatic Total</i>	2,323	145	2,468
<i>Agriculture</i>			
Cropland	2,617	4,024	6,641
Irrigated Pasture-Grassland	60	891	951
Orchards	—	—	0
Vineyards	—	29	29
<i>Agriculture Total</i>	2,677	4,944	7,621
<i>Non-Habitat Land Cover Type</i>			
Disturbed	2	3	5
High-density Development	1	—	1
Low-density Development	35	201	236
Major Roads	3	3	6
<i>Non-Habitat Land Cover Type Total</i>	41	207	248
Grand Total	8,944	5,497	14,441

Note: Due to the relatively coarse scale of the land cover mapping, rounding is applied to acreages 10 or greater. For acreages of 10–100, the acreage is rounded to the nearest 5 acres. For acreages greater than 100, the acreage is rounded to the nearest 10 acres. All acreages greater than 10 should be considered approximations.

3.2.10 Upper Cosumnes River Watershed

3.2.10.1 Land Cover Types

The Upper Cosumnes River watershed is located in the east-central portion of the Plan Area, which encompasses about 28% (31,885 acres) of the watershed (Table 1, Figure 2). The majority of the watershed in the Plan Area (21, 0810 acres, or 66%), consists of Terrestrial habitat by Valley Grassland (Table 2, Figure 3). Agricultural areas comprise about 11% and aquatic areas comprise about 5% of the watershed in the Plan Area. Non-habitat land cover, primarily Low-Density Development, covers the remaining 18% of the watershed. Impervious surfaces cover approximately 341 acres, or only 1%, of the watershed.

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3.2.10.2 Hydrology

According to the NHD flowline dataset, approximately 62% of the Upper Cosumnes River watershed consists of stream/river features (Table 3, Figure 4). The majority of stream/river features in the watershed are tributaries to the Cosumnes River, which is mapped as an artificial path. The river and the Folsom South Canal account for most of the artificial path features mapped in the watershed. Less than 10% of the flowline features within the watershed include canal/ditch and connector or pipeline features.

3.2.10.3 Geological Formations

The Upper Cosumnes River watershed contains a variety of geological formations. Two formations total about 44% of the watershed and include the riverbank and Laguna formations (Table 4, Figure 5). Other prominent formations include Valley Springs, Mehrten, gopher ridge, and Modesto formations.

3.2.10.4 Soils

The majority of the soils within this watershed are subcategories of loam (87%)(Table 5, Figure 6). Approximately 3% of the watershed contains water, 3% clay, and 7% falls within the Other category. Most of the Other category (6%) is related to mining activities (pits, slickens and Xerorthents, dredge tailings, 2% to 50% slopes).

3.2.10.5 Slope and Elevation

While the majority of the Upper Cosumnes River watershed is on flat to gentle slopes with elevations ranging from 0–500 feet, a small percentage (0.4%) is located above 500 feet (Tables 6 and 7). This watershed contains the highest percentage of land with slopes between 20%–40% and greater than 40%. These areas occur along the eastern border of the Plan Area.

3.2.10.6 Covered Species

The Upper Cosumnes River watershed includes documented occurrences for 15 of the 28 Covered Species, including legenerie; Sanford's arrowhead; vernal pool fairy shrimp, vernal pool tadpole shrimp, valley elderberry longhorn beetle, western spadefoot, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, white-tailed kite, and western red bat.

This watershed contains 6% of documented occurrences of Covered Species within the Plan Area (Table 8). Most notably, the watershed contains 153 of the 156 known occurrences (98%)

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of valley elderberry longhorn beetle, with the largest concentration of occurrences along the Cosumnes River just south of Rancho Murieta. Other than the longhorn beetle, no other Covered Species with documented occurrences in the watershed occur at particularly high levels relative to the other watersheds, ranging from 4% of total occurrences in the Plan Area for vernal pool fairy shrimp to 12% for ferruginous hawk. Therefore, the 6% of the documented occurrences of all Covered Species in the Plan Area is skewed by the extremely high percentage of valley elderberry longhorn beetle occurrences.

The Upper Cosumnes River contains 1,078 acres of modeled habitat for the valley elderberry longhorn beetle, which is substantially more than some of the other watersheds (Table 9). However, the habitat model for the beetle is very general because it includes all riparian communities under the assumption that the host plant elderberry is present. Therefore, the moderate amount of modeled habitat in the watershed compared to modeled habitat in the American River watershed (48 acres), Lower Cosumnes River watershed (2,231 acres), and Snodgrass Slough watershed (1,767 acres) should not be interpreted as the Upper Cosumnes River watershed having relatively higher value for the species.

The Upper Cosumnes River watershed contains modest amounts of modeled habitat for covered vernal pool species, ranging from 2,091 acres for dwarf downingia to 11,163 acres for vernal pool invertebrates.

The Upper Cosumnes River watershed contains substantial acreages of modeled habitats for all of the covered bird species (except greater sandhill crane), including about 521 to 21,700 acres of modeled foraging habitat for Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, and white-tailed kite and about 20,945 acres of modeled nesting/foraging habitat for burrowing owl. The watershed also supports large amounts of modeled nesting habitat for covered birds that can use a variety or more broad-scale land cover types for nesting (e.g., valley grassland), including loggerhead shrike (18,608 acres), northern harrier (20,424 acres), and tricolored blackbird (19,324 acres). For covered birds that nest in riparian and woodland habitats, the watershed supports substantial modeled nesting habitat, including 3,028 acres for Cooper's hawk and white-tailed kite and 832 acres for Swainson's hawk. Due to a relatively small amount of croplands and its location in the eastern portion of the Plan Area, the Upper Cosumnes River watershed supports only 881 acres of high-value foraging habitat for Swainson's hawk, or only 1% of the total in the Plan Area. Twenty-four of the 293 Swainson's hawk nest sites in the Plan Area are in this watershed. Seven of 96 documented nest colonies for tricolored blackbird and 9 of 63 potential nest colonies are in the Upper Cosumnes River watershed. Five the six colonies were observed in 1992, with others in 2000. The six documented nest colonies have ranged in size from approximately 200 individuals to 5,000 individuals at two different sites in 1992. Approximately 16,200 individuals have been

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observed at the nest colonies over the surveys, or 10% of the approximately 158,330 individuals observed at nest colonies in the Plan Area. The Upper Cosumnes River has relatively low value for greater sandhill crane, with only 734 acres of modeled roosting habitat and 2,398 acres of modeled foraging habitat.

The Upper Cosumnes River watershed generally defines the northern boundary of the California tiger salamander's range in the Plan Area, and contains a substantial amount of modeled habitat for the species, including 700 acres of modeled aquatic habitat and 15,559 acres of modeled upland habitat. No high-value habitat for the species is present in the watershed and there are no documented occurrences. There are two occurrences of western spadefoot and no occurrences of western pond turtle in the watershed, but there is substantial modeled habitat for the two species, including 1,444 acres of modeled aquatic habitat and 20,002 acres of modeled upland habitat for western spadefoot, and 599 acres of modeled breeding/foraging habitat and 15,153 acres of modeled nesting/aestivation habitat for western pond turtle. The Upper Cosumnes River watershed has low value for giant garter snake, with only 78 acres of modeled upland habitat and 2 acres of modeled aquatic habitat.

The Upper Cosumnes River watershed supports large acreages of modeled habitat for the covered mammals, including more than 18,866 acres of modeled general habitat for American badger and about 19,186 acres of modeled foraging habitat and 3,679 acres of modeled roosting habitat for western red bat. The Upper Cosumnes River watershed supports a moderate amount of modeled habitat for Sanford's arrowhead (6,648 acres).

The Upper Cosumnes River watershed also contains federally designated Critical Habitat for Sacramento Orcutt grass (7 acres) and vernal pool fairy shrimp and vernal pool tadpole shrimp (1,431 acres that is habitat for both species).

3.2.10.7 Conservation Considerations

The Upper Cosumnes River watershed is entirely outside of the UDA and encompasses a large portion of PPU 5 and small sections of PPUs 6 and 7 (Table 11). One of the primary conservation considerations in this watershed is the valley elderberry longhorn beetle, with 98% of occurrences for this species in the Plan Area concentrated along the upper Cosumnes River. It generally has high wildlife habitat value for the covered bird species (except greater sandhill crane), California tiger salamander, western spadefoot, western pond turtle, American badger, and western red bat. It has relatively low value for the covered plant species, vernal pool invertebrates, and giant garter snake.

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This watershed currently contains 3,358 acres of existing conservation, which are patchily distributed throughout the watershed (Table 20, Figure 10). Approximately 2,801 acres of the watershed are planned conservation. PPU 5 contains the majority of both existing and planned conservation. Valley grassland will comprise the majority of total conservation for this watershed, with the primary focus on connecting the Landscape Preserve in the Laguna Creek Watershed (PPU 7) with the Cosumnes River. Also, riparian restoration is planned for 890 acres of the watershed, and will be focused along the Cosumnes River. This watershed will contain approximately two-thirds of the riparian restoration within the Plan Area. The riparian restoration will provide both resident and nesting habitat for many of the Covered Species and will provide cover and refuge for species using the river as movement corridors. Importantly, the riparian restoration will provide resident and dispersal habitat for the valley elderberry longhorn beetle along the Cosumnes River.

Table 20
Summary of Conserved Land Cover Types in the Upper Cosumnes River Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
<i>Terrestrial</i>			
Blue Oak Woodland	443	—	443
Mine Tailing Riparian Woodland	7	—	7
Mixed Riparian Scrub	21	38	59
Mixed Riparian Woodland	55	376	431
Valley Grassland	2,453	1,479	3,932
<i>Terrestrial Total</i>	2,979	1,893	4,872
<i>Aquatic</i>			
Freshwater Marsh	7	<1	7
Open Water	10	—	10
Seasonal Wetland	46	31	77
Streams/Creeks	26	129	155
Swale	26	9	35
Vernal Pool	87	38	125
<i>Aquatic Total</i>	202	207	409
<i>Agriculture</i>			
Cropland	54	404	458
Irrigated Pasture-Grassland	20	23	43
Orchards	—	116	116
Vineyards	3	10	13
<i>Agriculture Total</i>	77	553	630
<i>Non-Habitat Land Cover Type</i>			
Disturbed	49	<1	49
High-density Development	1	—	1

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

Table 20
Summary of Conserved Land Cover Types in the Upper Cosumnes River Watershed

Land Cover Types	Existing Conservation (acres)	Planned Conservation (acres)	Total Conservation (acres)
Low-density Development	13	146	159
Major Roads	1	2	3
Mine Tailings	36	<1	36
<i>Non-Habitat Land Cover Type Total</i>	<i>100</i>	<i>148</i>	<i>248</i>
Grand Total	3,358	2,801	6,159

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Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

4 SUMMARY

Although all of the watersheds in the Plan Area support important biological resources, as described in the above sections, 5 of the 10 watersheds in the Plan Area stand out as relatively important for protection in the Plan Area: Laguna Creek, Lower Cosumnes River, Upper Cosumnes River, Morrison Creek, and Snodgrass Slough. The attributes that make these five watersheds particularly important for protection are summarized below.

Laguna Creek

The Laguna Creek watershed contains several attributes that make it important for conservation:

- It is the largest watershed in the Plan Area at 73,976 acres, or 76% of the Plan Area.
- It contains virtually all of the mapped land covers in the Plan Area, 91% of the watershed is undeveloped, and only 2% of the watershed is impervious surfaces.
- It contains 42% of the vernal pool in the Plan Area.
- It contains 26% of the flowline types in the Plan Area, of which 86% are natural stream/river.
- 29% of the watershed is Laguna formation, which is associated with vernal pools.
- It contains documented occurrences of 23 of the 28 Covered Species, including 19% of all Covered Species occurrences in the Plan Area, 20% of the vernal pool plant occurrences, 37% of the vernal pool invertebrate occurrences, 79% of the California tiger salamander occurrences, 58% of the western spadefoot occurrences, and 44% of western pond turtle occurrences.
- It contains large amounts of modeled habitats for all of the covered reptile, amphibian, bird, and mammal species. There are 10,092 acres of high-value habitat for Swainson's hawk. It contains 42 Swainson's hawk nest sites, 20 documented and 27 potential tricolored blackbird nest colonies, including a documented nest colony supporting approximately 6,750 individuals, and 7 roosting sites for greater sandhill crane.
- It contains federally designated Critical Habitat for California tiger salamander (8,758 acres), Sacramento Orcutt grass (24,510 acres), and vernal pool fairy shrimp and vernal pool tadpole shrimp (27,048 acres).
- It already contains 18,315 acres of existing conservation, including the 12,500-acre Chance Ranch.

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Lower Cosumnes River

The Lower Cosumnes River watershed contains several attributes that make it important for conservation:

- 82% of the watershed is terrestrial habitat and agriculture and 8% is aquatic. Only 2% of the watershed is impervious surfaces.
- The lower Cosumnes River and Badger Creek are prominent features in the watershed.
- It contains documented occurrences of 19 of the 28 Covered Species, including 15% of all Covered Species occurrences in the Plan Area; 20% of the occurrences of greater sandhill crane; 23%–35% of occurrences of Cooper’s hawk, loggerhead shrike, northern harrier, Swainson’s hawk, and white-tailed kite; and 5 of the 14 documented occurrences for giant garter snake.
- It contains large amounts of modeled habitats for all of the covered reptile, amphibian, bird, and mammal species. 25,942 acres of high-value habitat are available for Swainson’s hawk.
- It contains 90 Swainson’s hawk nest sites and 29 roost sites for greater sandhill crane.
- It contains federally designated Critical Habitat for Sacramento Orcutt grass (1,842 acres) and vernal pool fairy shrimp and vernal pool tadpole shrimp (2,069 acres).
- It already contains 14,263 acres of existing conservation, including the Stone Lakes NWR and Cosumnes River Preserve.

Upper Cosumnes River

The Upper Cosumnes River watershed contains several attributes that make it important for conservation:

- 66% of the watershed is undeveloped, with valley grassland the dominant land cover. Only 1% of the watershed is impervious surfaces.
- The upper Cosumnes River is the prominent landscape feature in the watershed and 62% of the flowlines in the watershed are stream/river features.
- It contains documented occurrences of 15 of the 28 Covered Species, including 98% of the valley elderberry longhorn beetle occurrences concentrated along the Cosumnes River.
- It contains large amounts of modeled habitats for all of the covered bird species (except greater sandhill crane), California tiger salamander, western spadefoot, western pond

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

turtle, American badger, and western red bat. High-value habitat includes 881 acres for Swainson's hawk.

- It contains federally designated Critical Habitat for Sacramento Orcutt grass (7 acres) and vernal pool fairy shrimp and vernal pool tadpole shrimp (1,431 acres).
- It already contains 3,358 acres of existing conservation distributed throughout the watershed.

Morrison Creek

The Morrison Creek watershed contains several attributes that make it important for conservation:

- It is the fourth-largest watershed in the Plan Area at 42,926 acres, or 61%, of the Plan Area and comprises the large majority of the UDA.
- Undeveloped portions of the watershed support substantial areas of vernal pool and swale embedded within more than 21,294 acres of valley grassland.
- 83% of the flowline features are stream and river features, including Morrison Creek, Laguna Creek (north), Elder Creek, Strawberry Creek, Unionhouse (Beacon) Creek, and Frye Creek.
- The Laguna Creek Wildlife Corridor is a prominent landscape feature in the watershed that provides nesting, resident, and movement habitat for many of the Covered Species, including western pond turtle, giant garter snake, and tricolored blackbird.
- 48% of the watershed is Laguna formation, which is associated with vernal pools.
- It contains documented occurrences of 23 of the 28 Covered Species, including 16% of all Covered Species occurrences in the Plan Area 43% of the covered vernal pool plant species occurrences, 53% of the covered vernal pool invertebrate species occurrences, 29% of the western spadefoot occurrences, 19% of the Sanford's arrowhead occurrences, 7% of the giant garter snake occurrences, and 2% of the western pond turtle occurrences.
- It contains large amounts of modeled habitat for all of the Covered Species (except California tiger salamander). High-value habitat includes 1,388 acres for giant garter snake and 1,926 acres for Swainson's hawk.
- It contains 42 documented and 16 potential nest colonies for tricolored blackbird.
- It contains federally designated Critical Habitat for Sacramento and slender Orcutt grass (1,161 acres) and vernal pool fairy shrimp and vernal pool tadpole shrimp (2,451 acres).
- It already contains 2,888 acres of existing conservation focused on valley grasslands and vernal pools.

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Snodgrass Slough

The Snodgrass Slough watershed contains several attributes that make it important for conservation:

- It is the fifth largest watershed in the Plan Area and contains large areas of agriculture and aquatic habitats in the western portion of the Plan Area. About 3% of the watershed is impervious surfaces.
- It contains documented occurrences of 18 of the 28 Covered Species, including 17% of all Covered Species occurrences in the Plan Area, 70% of the occurrences of dwarf downingia, 21% of the occurrences of legenere, 27% of the occurrences of mid-valley fairy shrimp, 56% of the occurrences of Sanford's arrowhead, 50% of the occurrences of giant garter snake, 28% of the occurrences of western pond turtle, 32% of the occurrences of Swainson's hawk, and 23% of the occurrences of greater sandhill crane.
- It contains large amounts of modeled habitats for most of the Covered Species. High-value habitat includes 6,050 acres for giant garter snake and 28,340 acres for Swainson's hawk and 26,848 acres for greater sandhill crane. Along with the Lower Cosumnes River watershed, it is critical for conservation of Swainson's hawk foraging habitat, with the watersheds accounting for 72% of the high-value habitat.
- It contains 86 Swainson's hawk nest sites and 12 greater sandhill crane roost sites.
- It already contains 8,944 acres of existing conservation, including aquatic habitats that are important habitats for many of the Covered Species.

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

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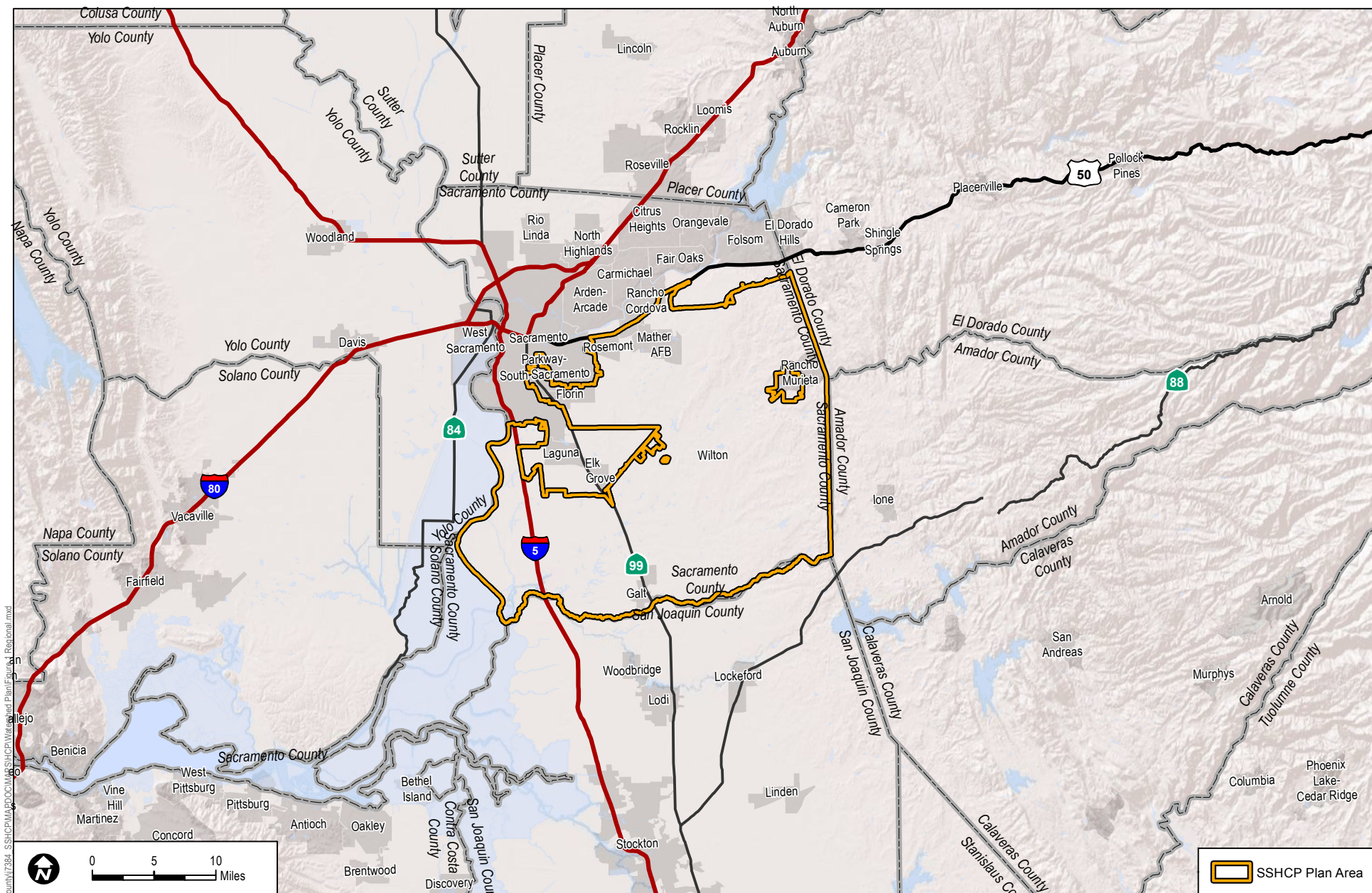
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SOURCE: ESRI, County of Sacramento 2014

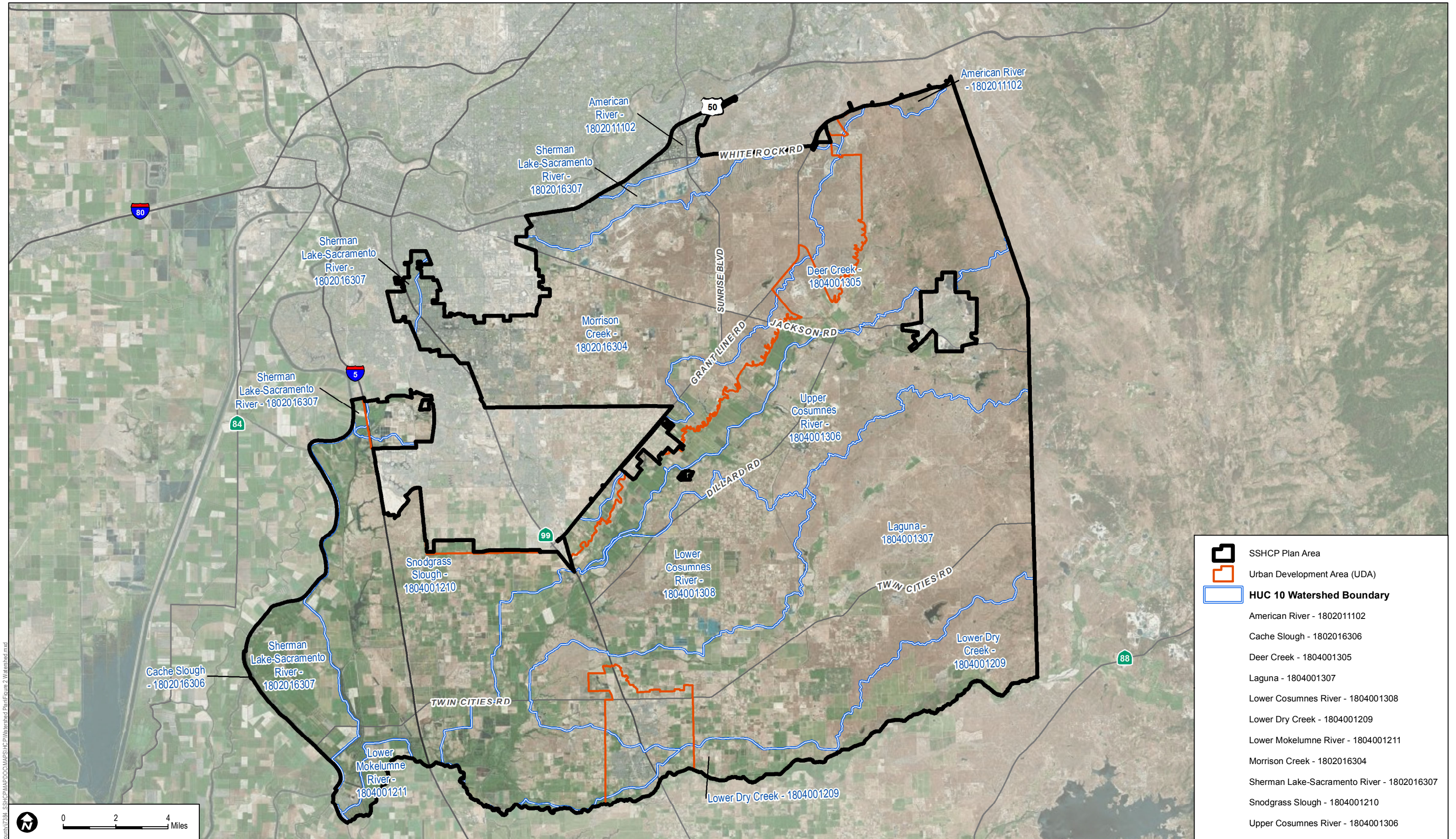
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 1
Regional

Watershed Study for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

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- SSHCP Plan Area
- Urban Development Area (UDA)
- HUC 10 Watershed Boundary
- American River - 1802011102
- Cache Slough - 1802016306
- Deer Creek - 1804001305
- Laguna - 1804001307
- Lower Cosumnes River - 1804001308
- Lower Dry Creek - 1804001209
- Lower Mokelumne River - 1804001211
- Morrison Creek - 1802016304
- Sherman Lake-Sacramento River - 1802016307
- Snodgrass Slough - 1804001210
- Upper Cosumnes River - 1804001306

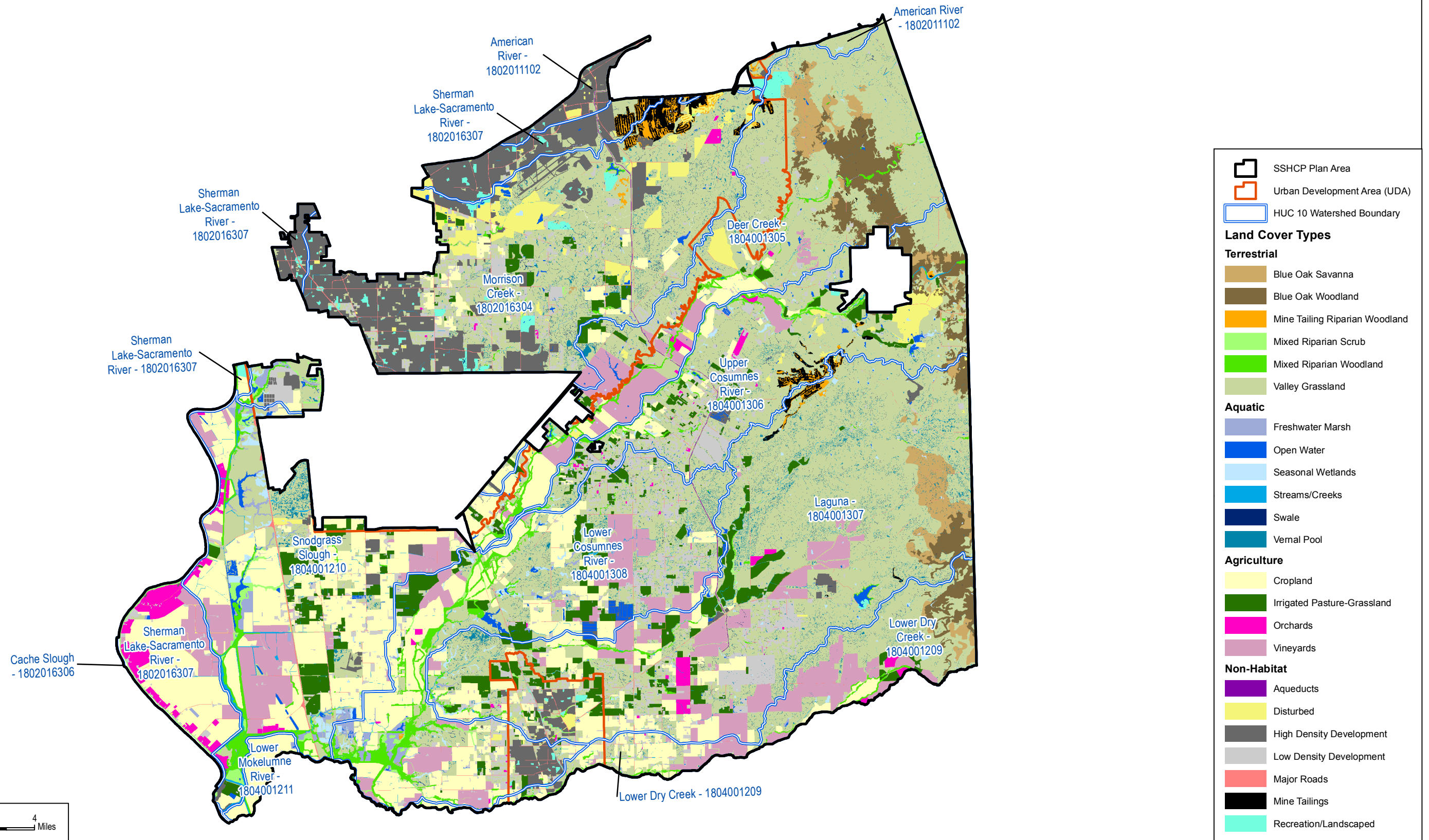
FIGURE 2
Watersheds

SOURCE: Bing Maps 2015, USGS 2013 National Hydrography Dataset (NHD)

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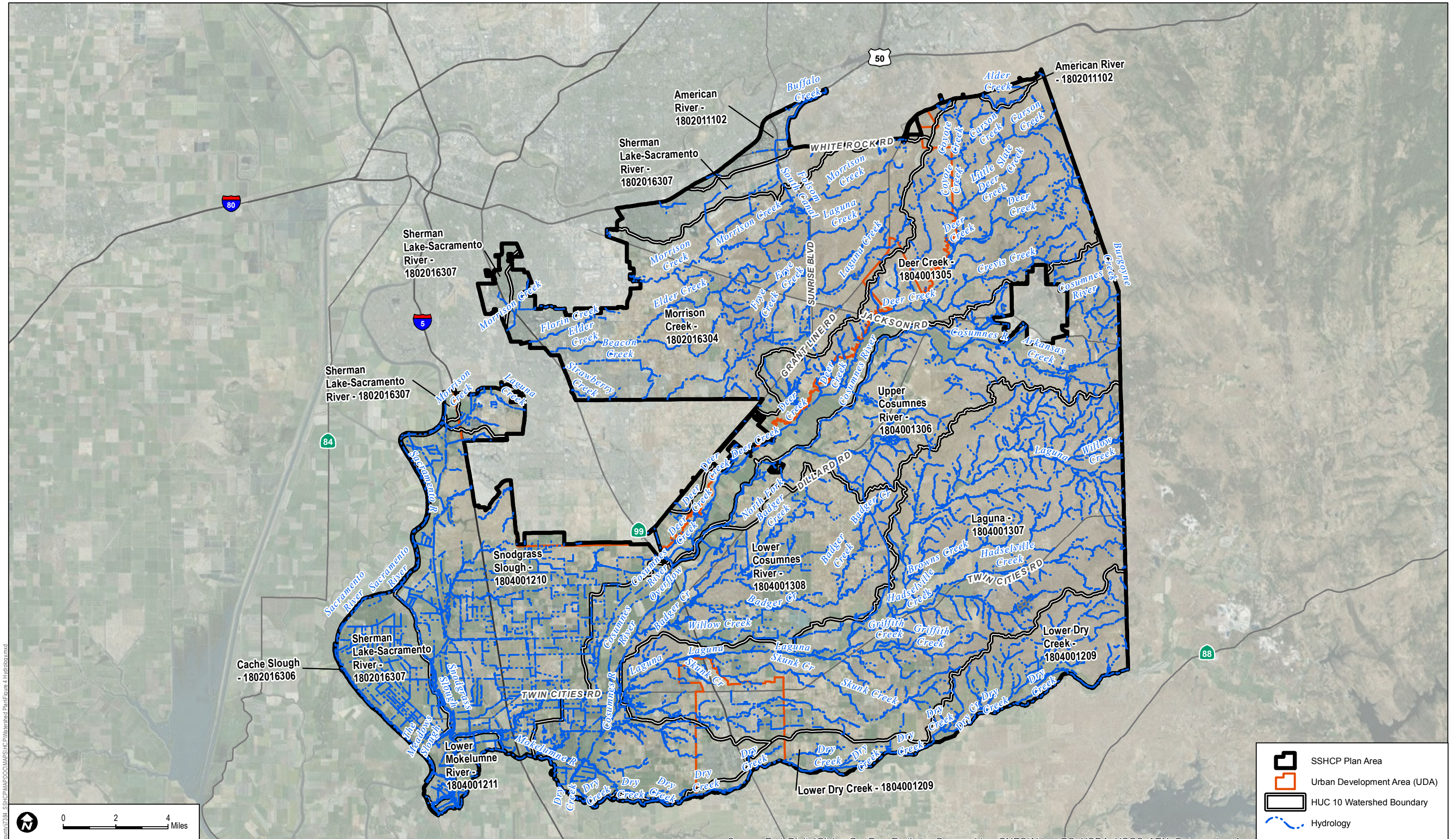
SOURCE: USGS 2013 National Hydrography Dataset (NHD)

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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 3
Land Cover

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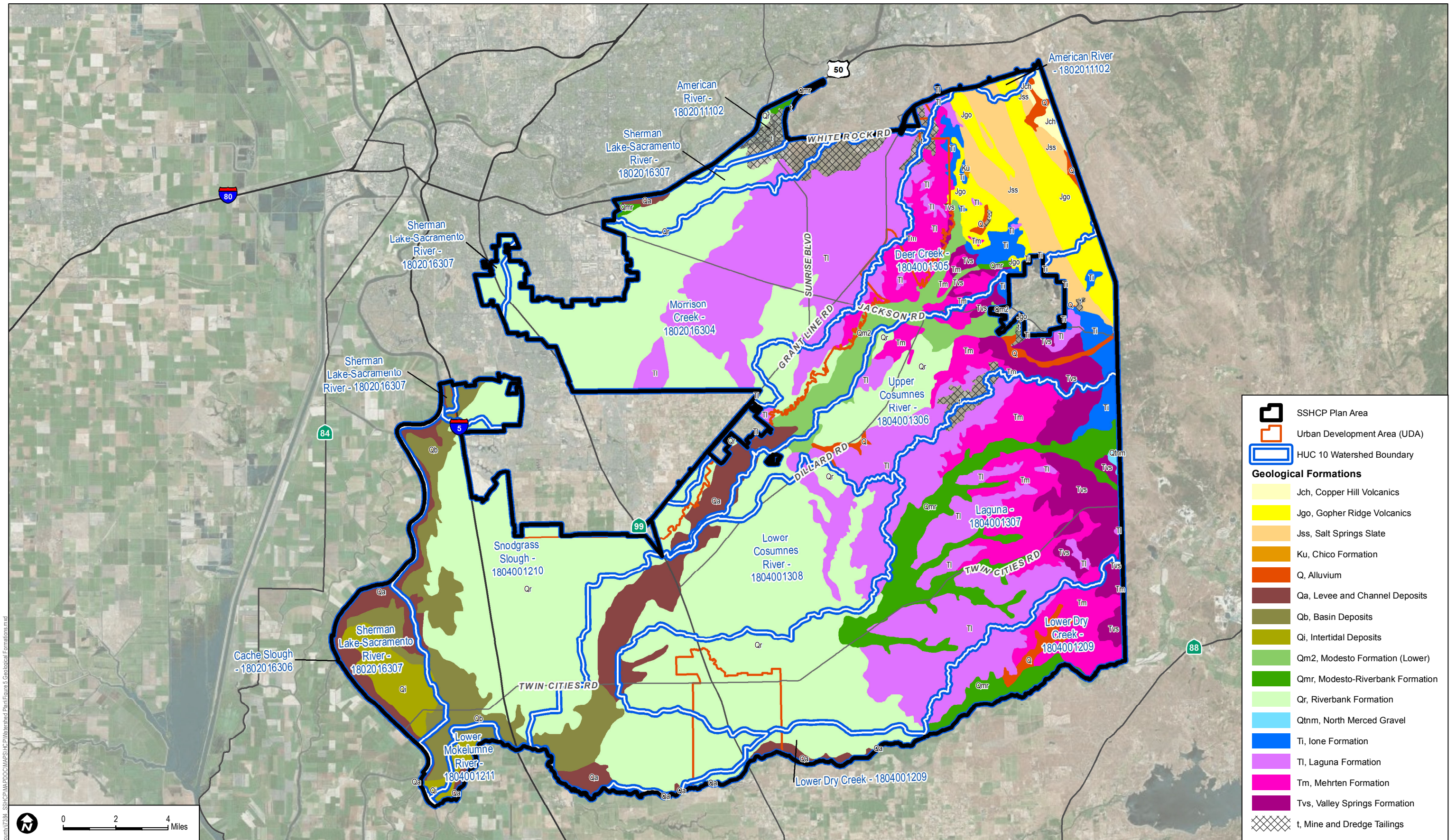
SOURCE: USGS 2013 National Hydrography Dataset (NHD), County of Sacramento 2012

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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 4
Hydrology

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SOURCE: Bing Maps 2015, County of Sacramento 2014, CA Geologic Survey 1981

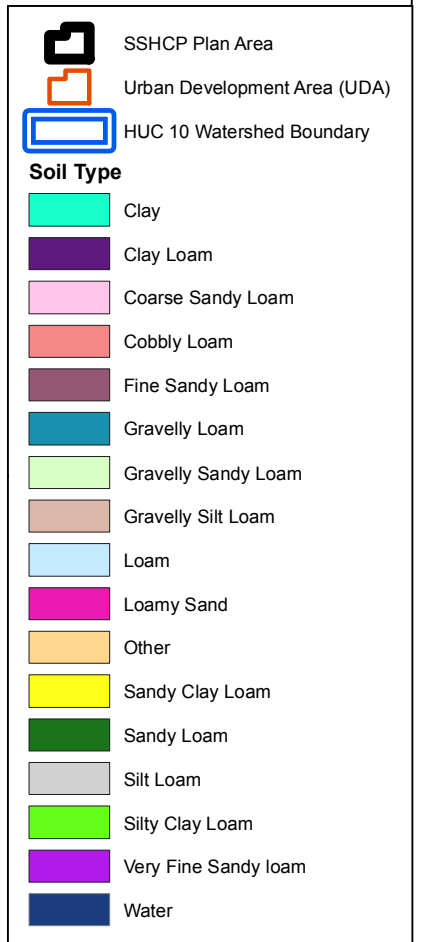
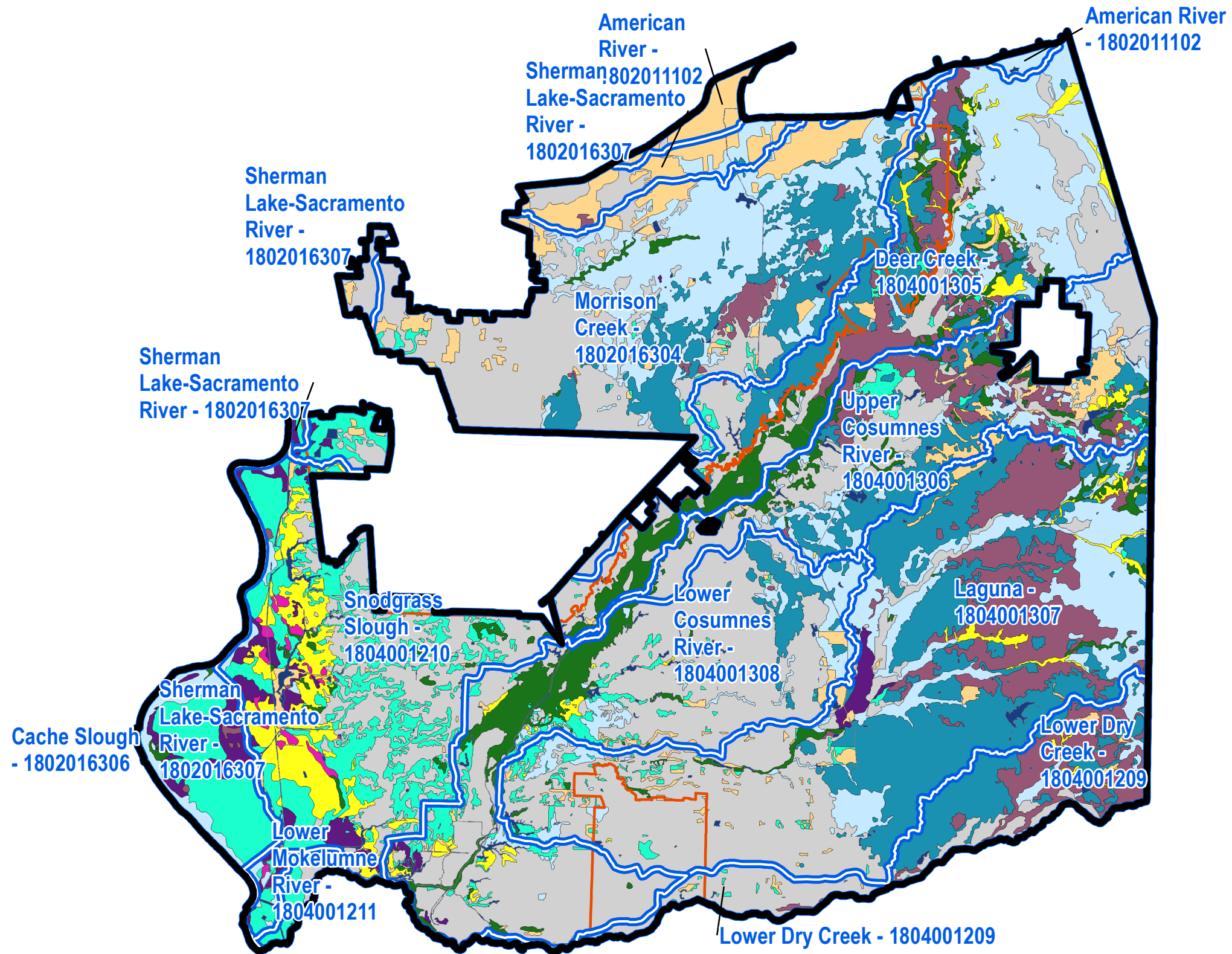
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 5
Geological Formations

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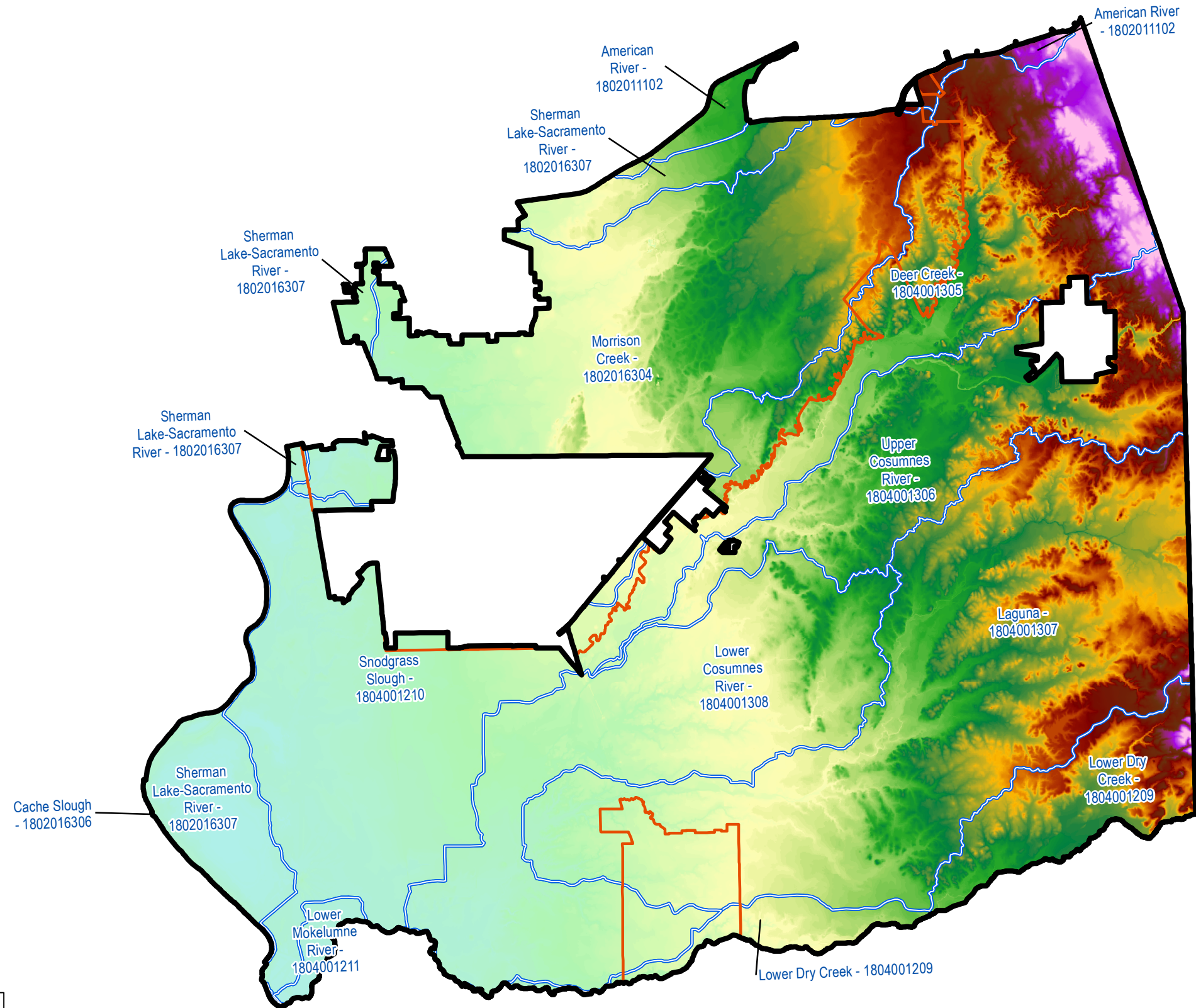
SOURCE: National Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database 2009

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 6
Soils

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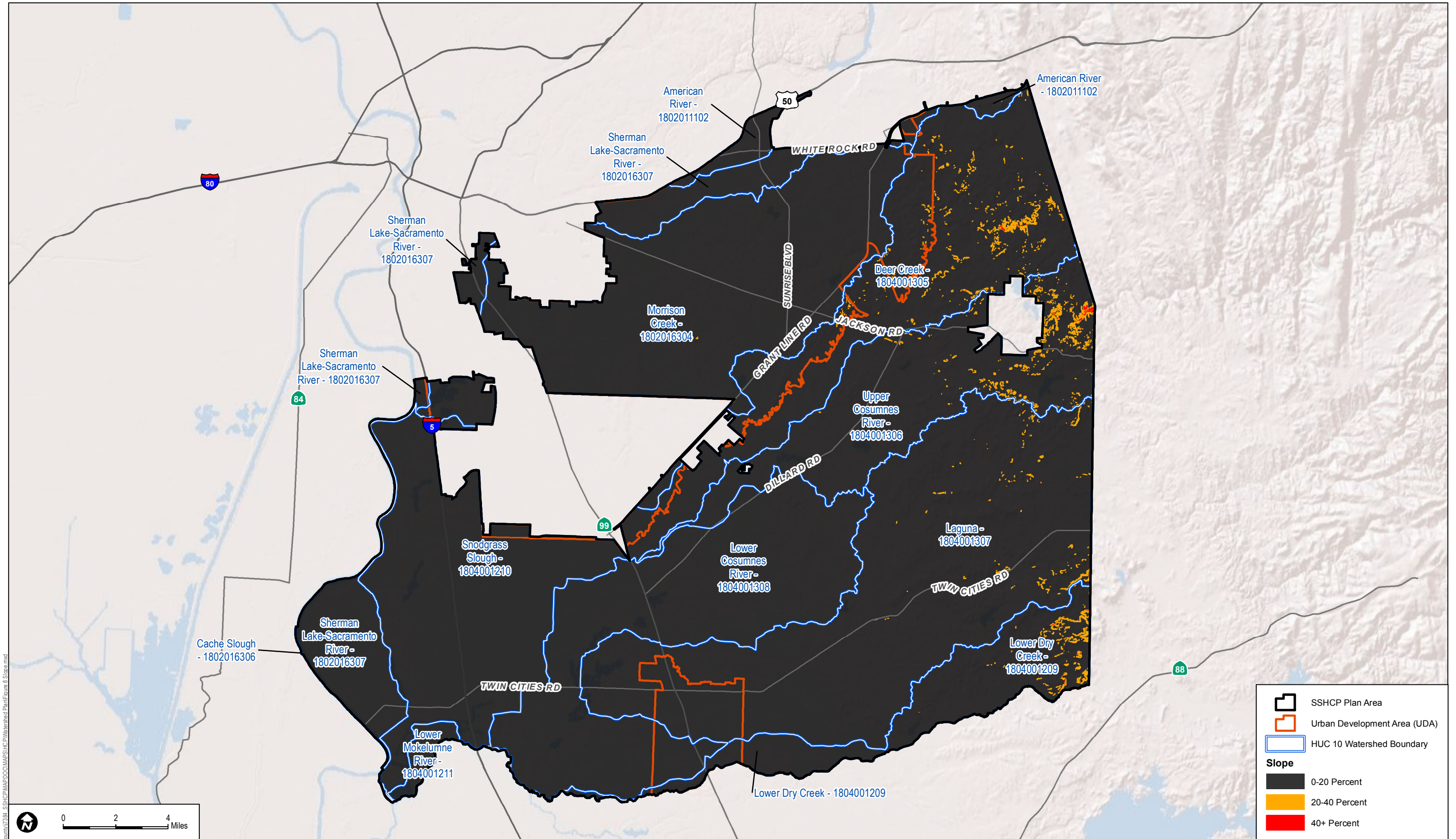
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SOURCE: USGS National Elevation Dataset (2010)

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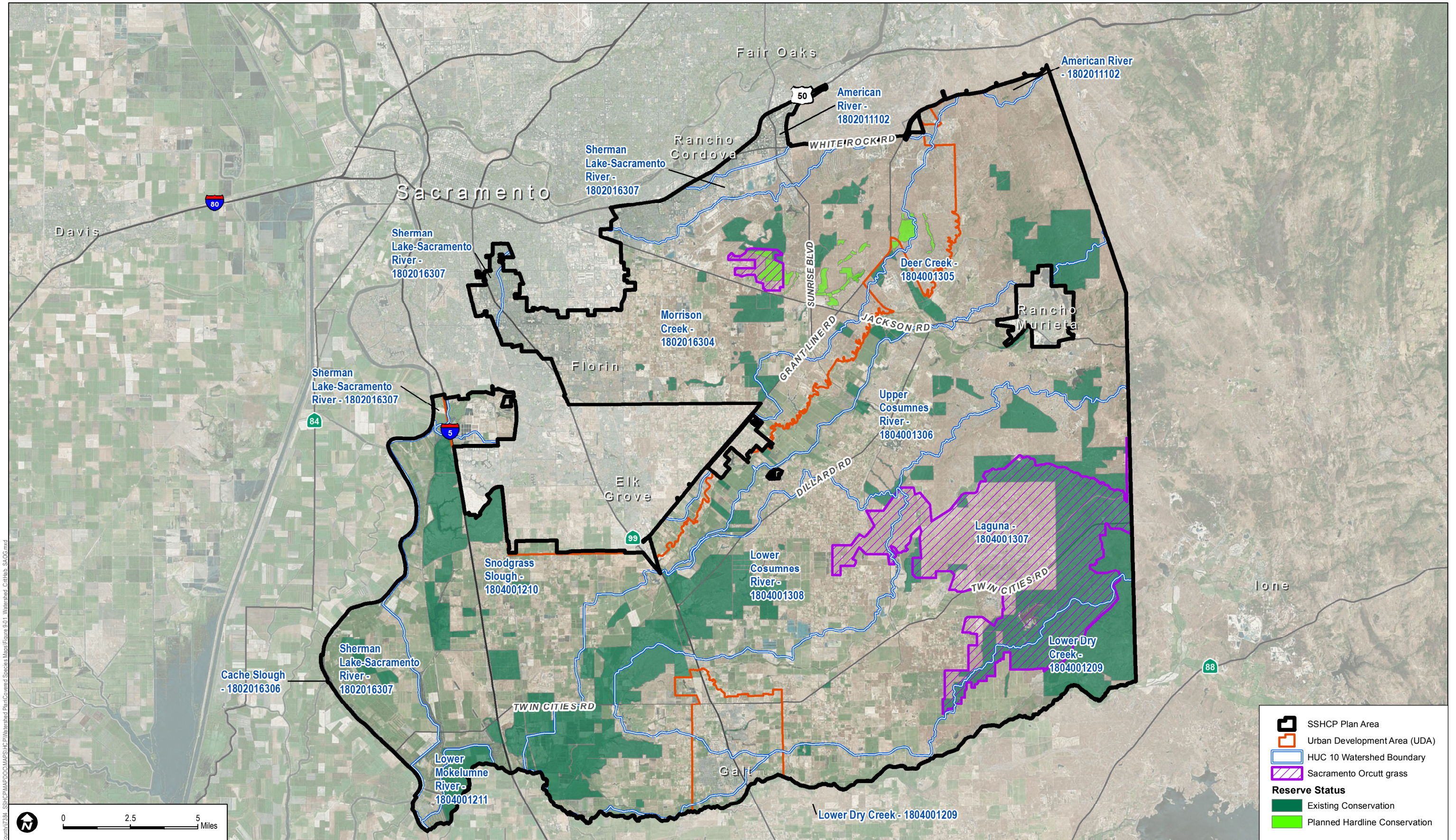
FIGURE 7
Elevation

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SSHCP Plan Area

Urban Development Area (UDA)

HUC 10 Watershed Boundary

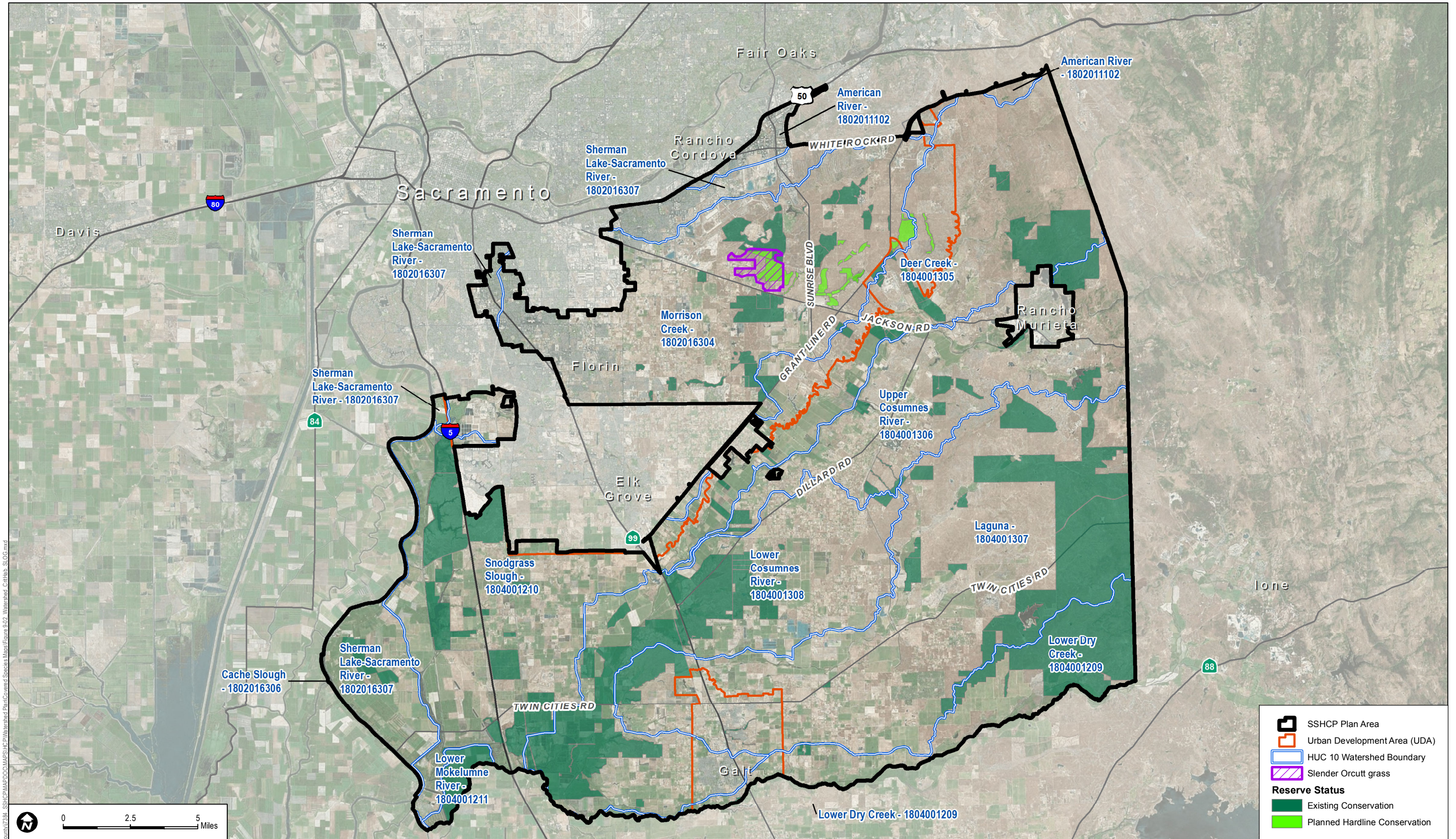
Sacramento Orcutt grass

Reserve Status

Existing Conservation

Planned Hardline Conservation

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SOURCE: Bing Maps, USGS 2013 NHD, USFWS 2012

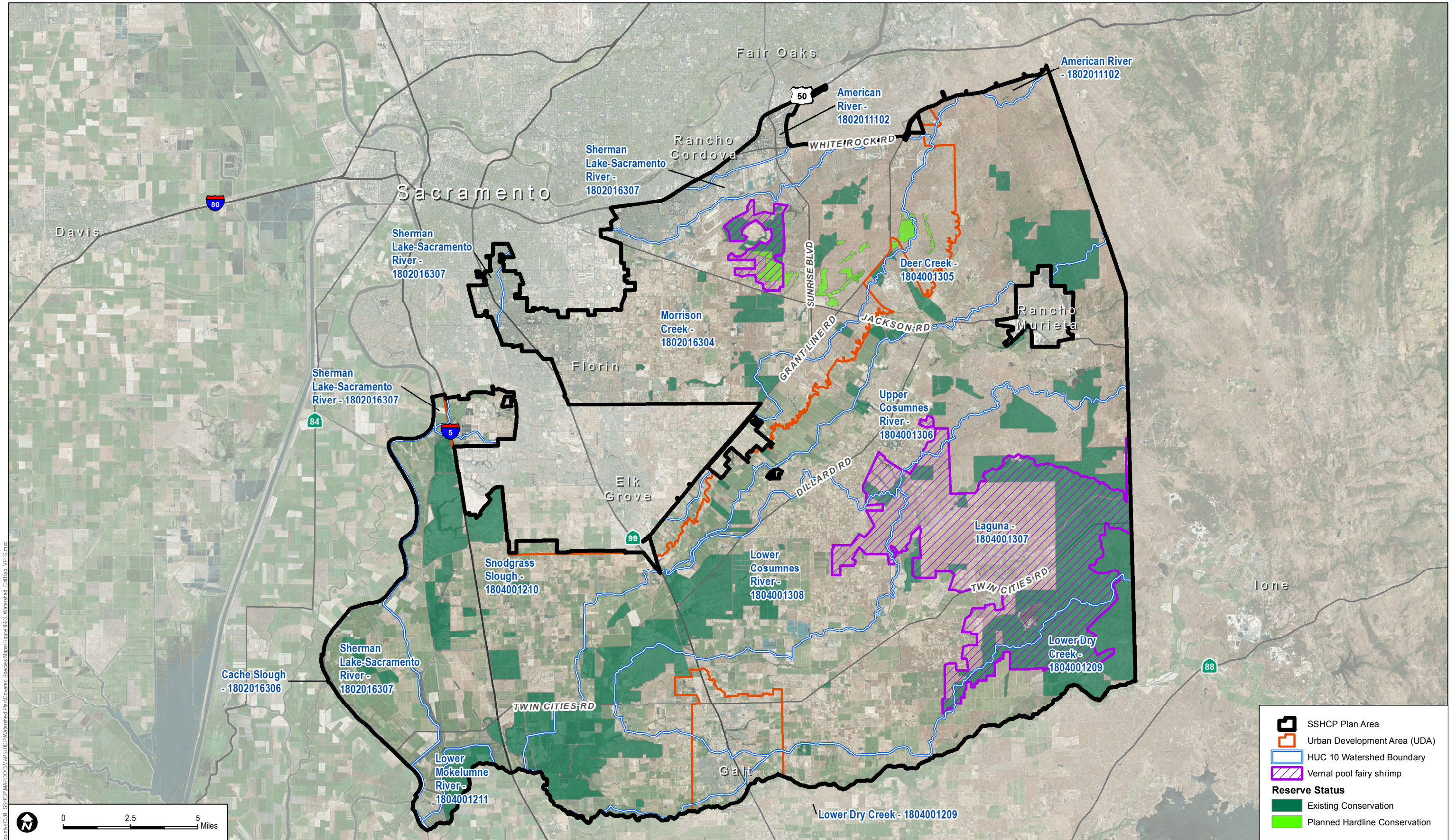
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-2
Critical Habitat for Slender Orcutt Grass

Figure depicts existing preserves and hard-line planned conservation only. For a description of soft-line planned conservation see Sections 7.5.2 and 7.5.3 of the HCP.

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SOURCE: Bing Maps, USGS 2013 NHD, USFWS 2012

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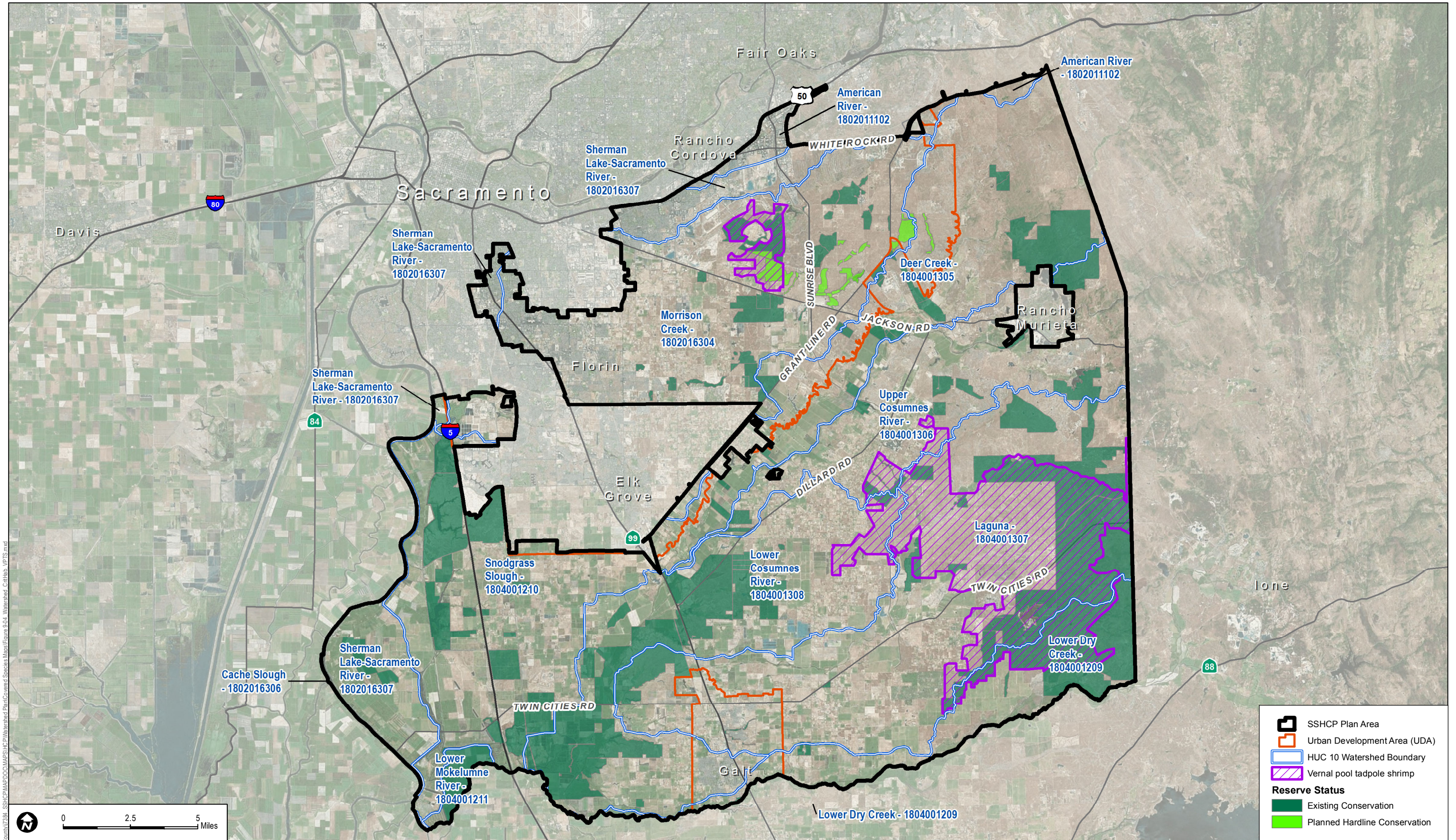
SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-3

Critical Habitat for Vernal Pool Fairy Shrimp

Figure depicts existing preserves and hard-line planned conservation only. For a description of soft-line planned conservation see Sections 7.5.2 and 7.5.3 of the HCP.

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SOURCE: Bing Maps, USGS 2013 NHD, USFWS 2012

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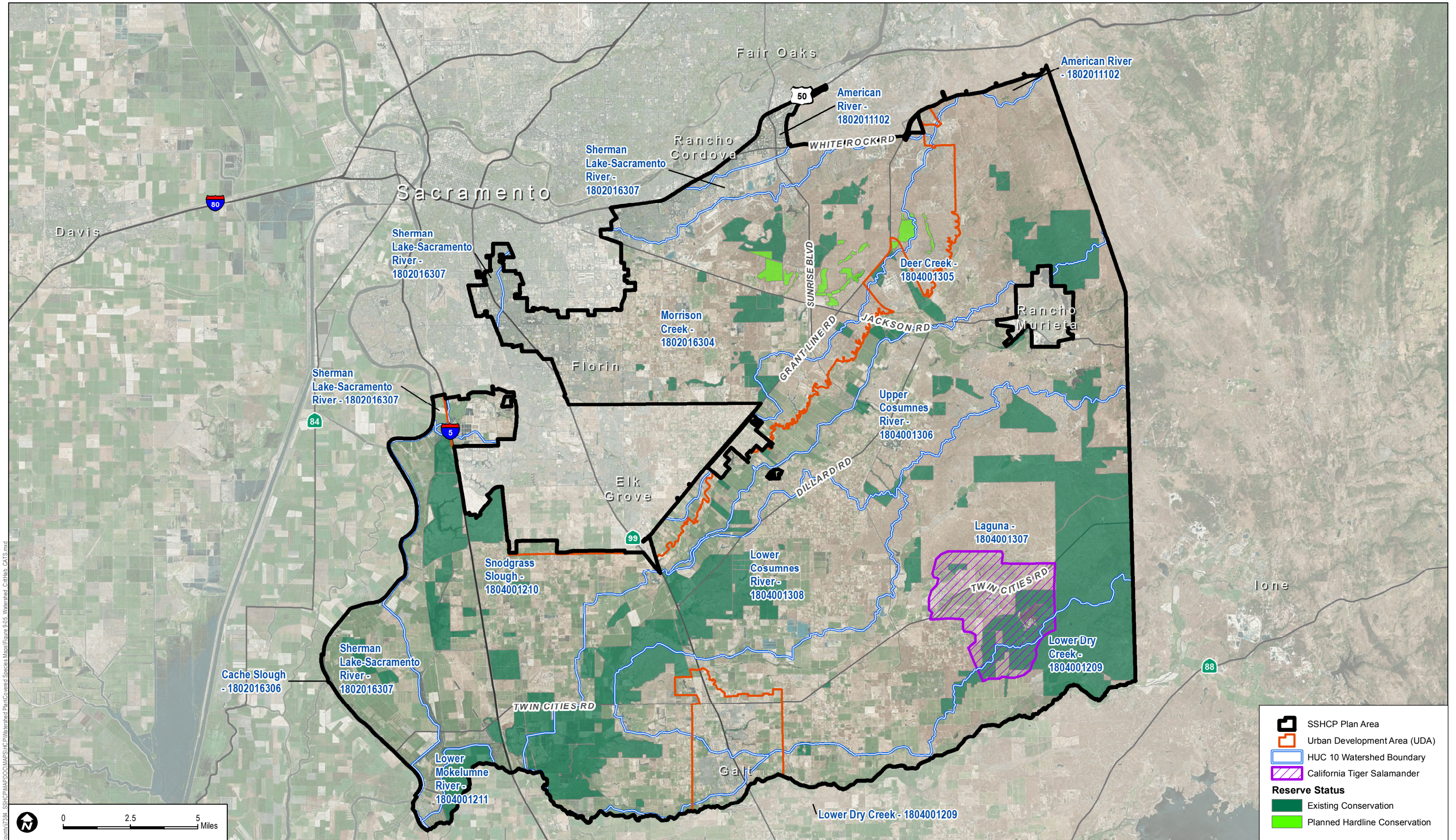
SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-4

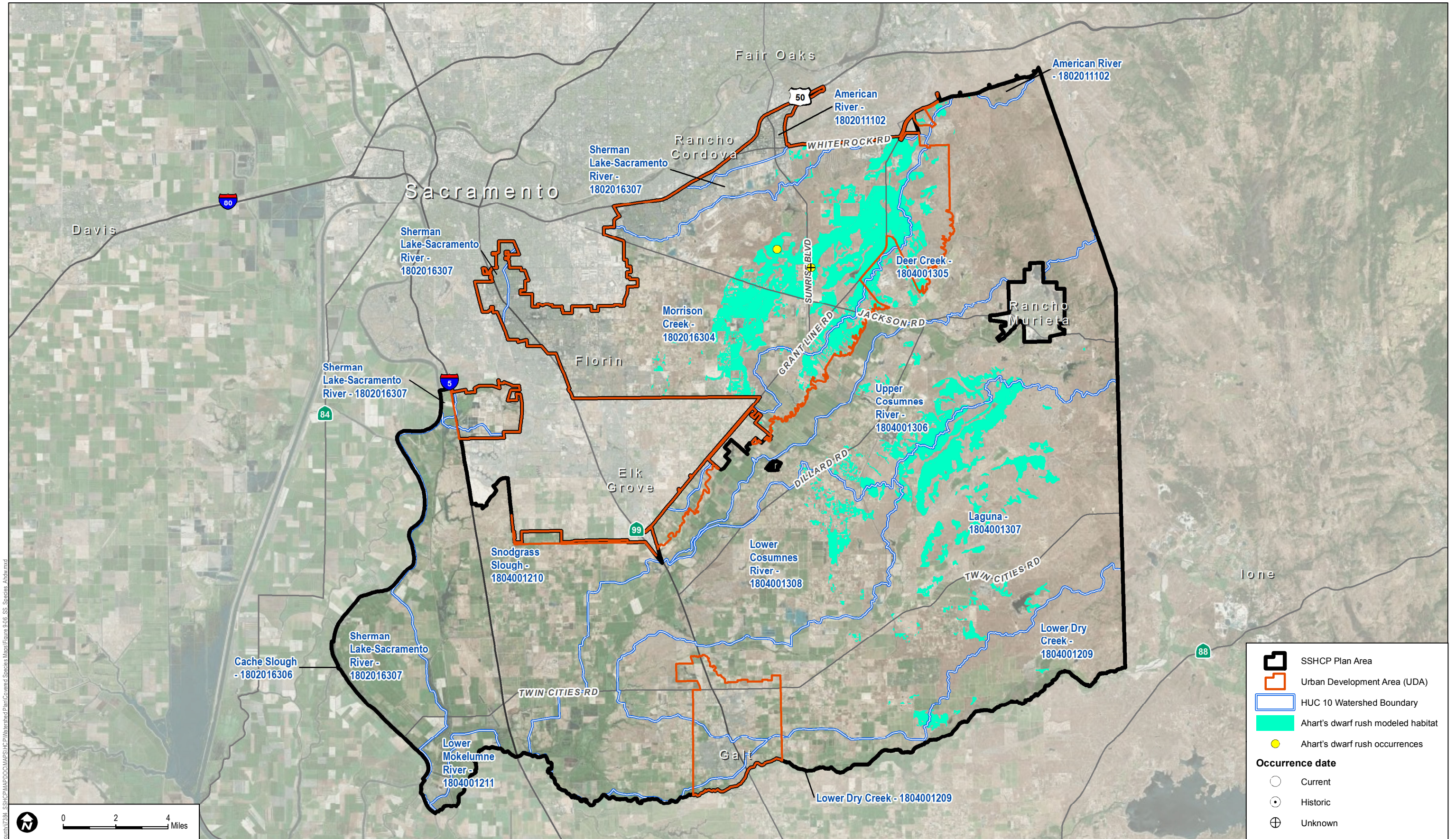
Critical Habitat for Vernal Pool Tadpole Shrimp

Figure depicts existing preserves and hard-line planned conservation only. For a description of soft-line planned conservation see Sections 7.5.2 and 7.5.3 of the HCP.

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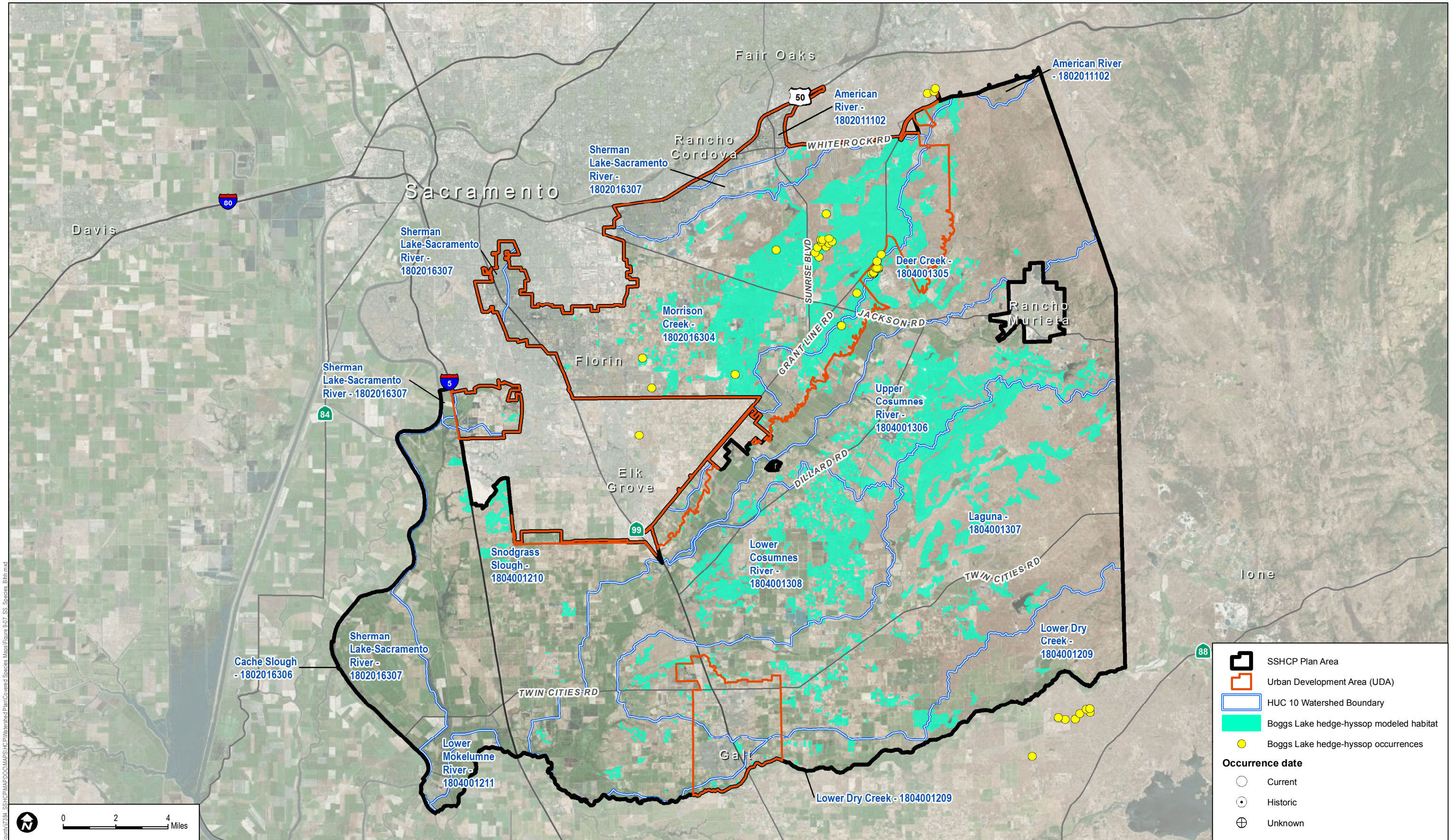
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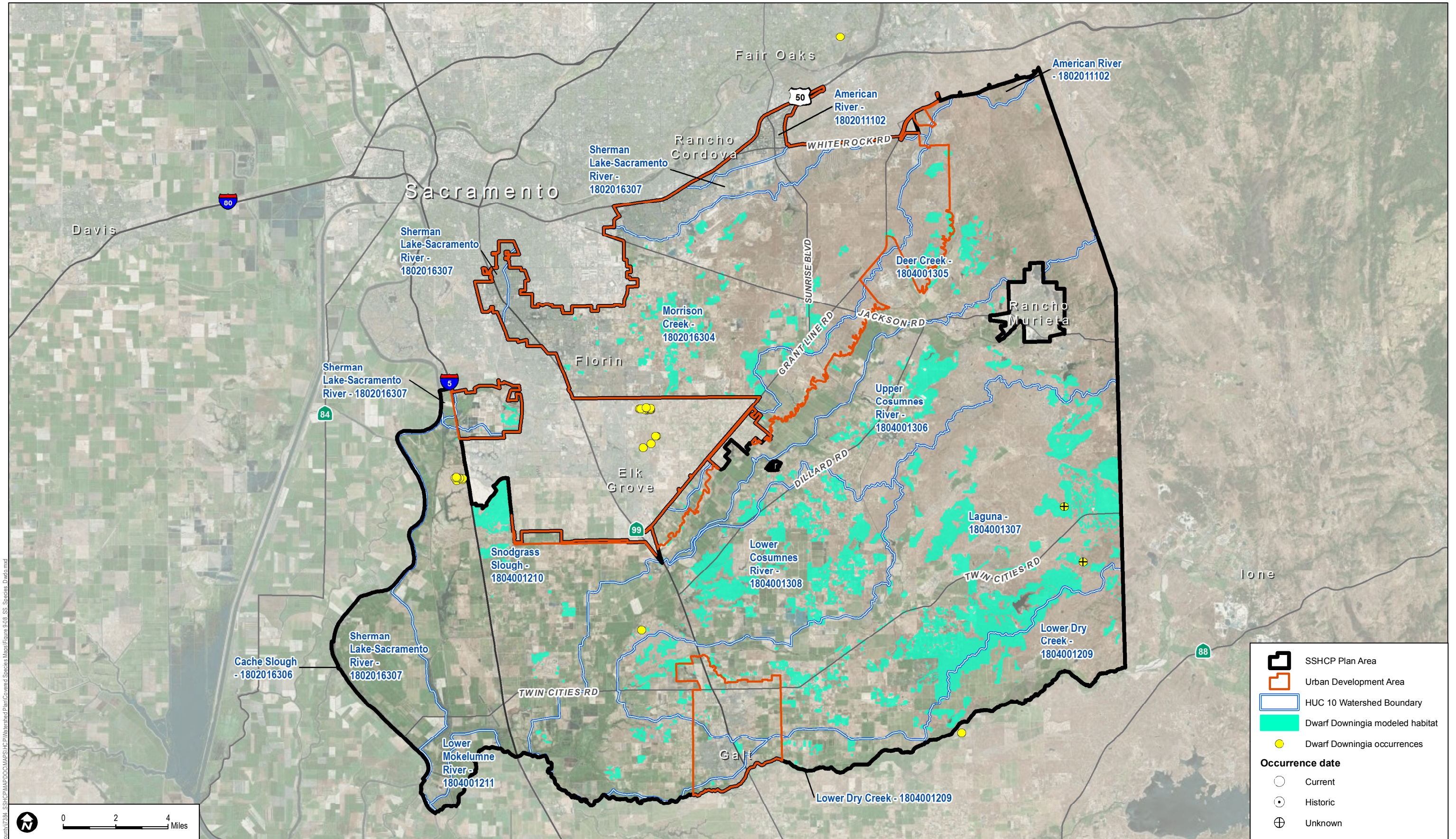
FIGURE 9-6
Ahart's Dwarf Rush Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDB points are centroids of CNDDB polygons of variable certainty.

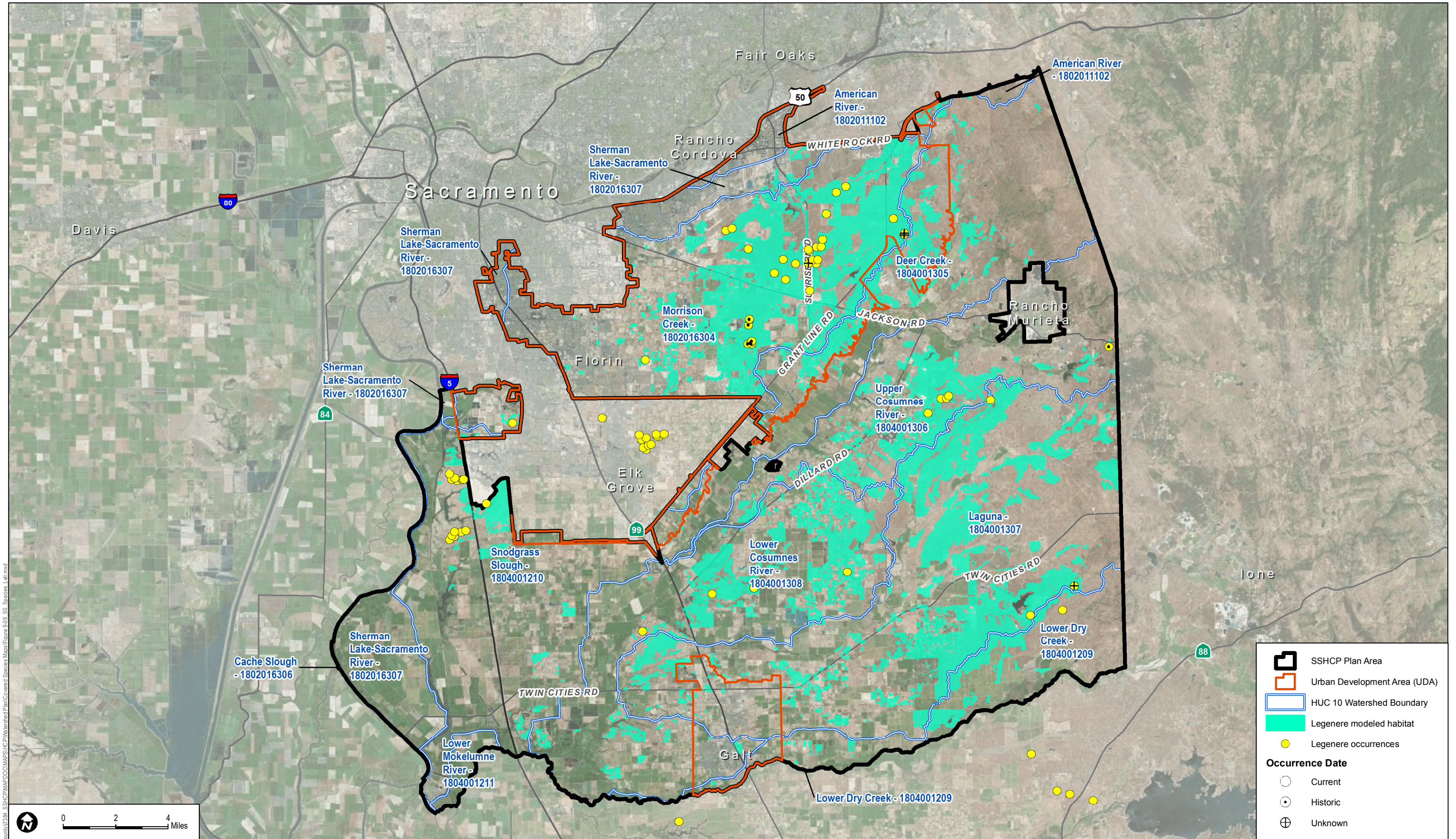
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SOURCE: Bing Maps, County of Sacramento 2015, CDFG 2012, USGS 2013 NHD

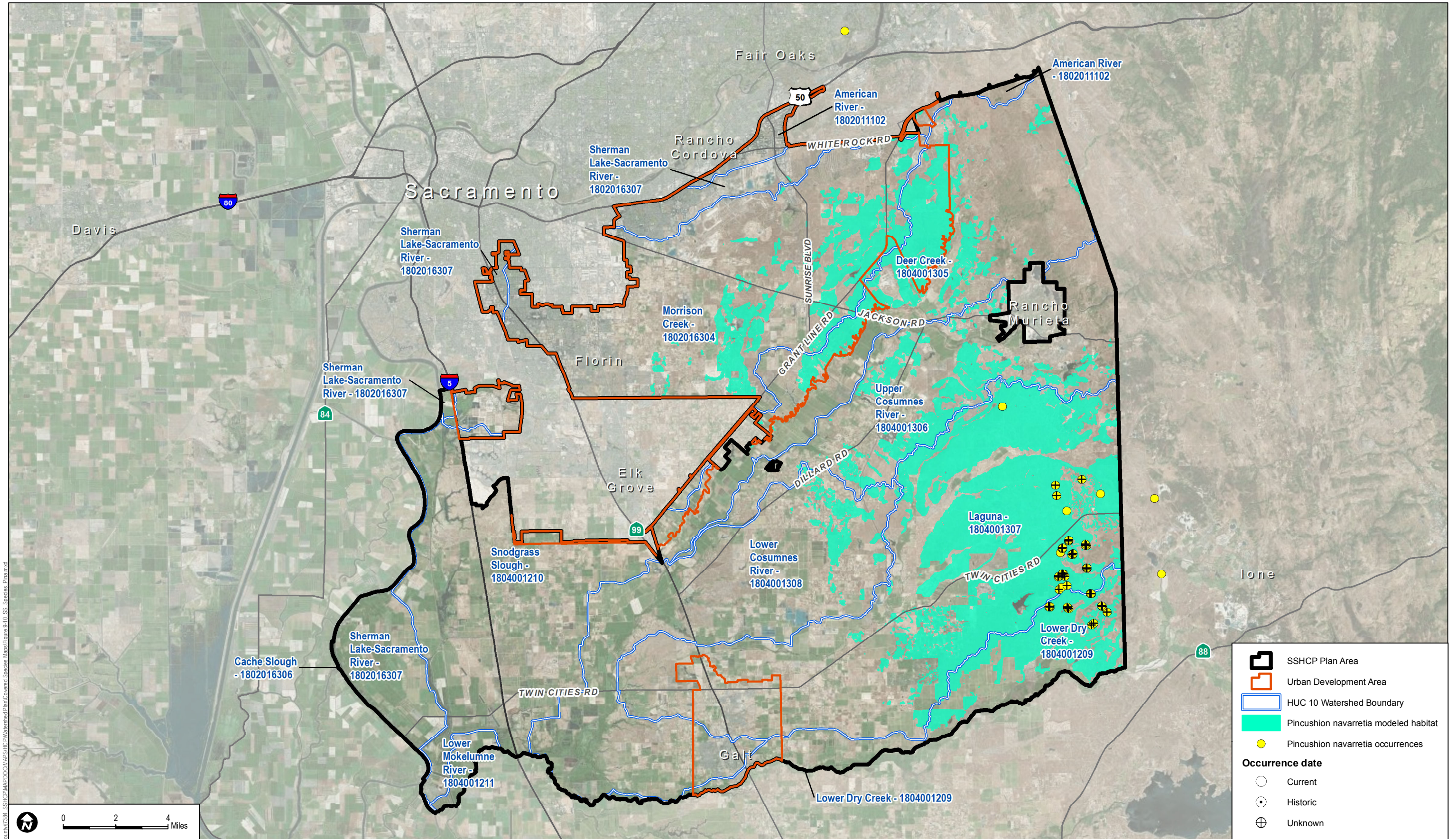
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

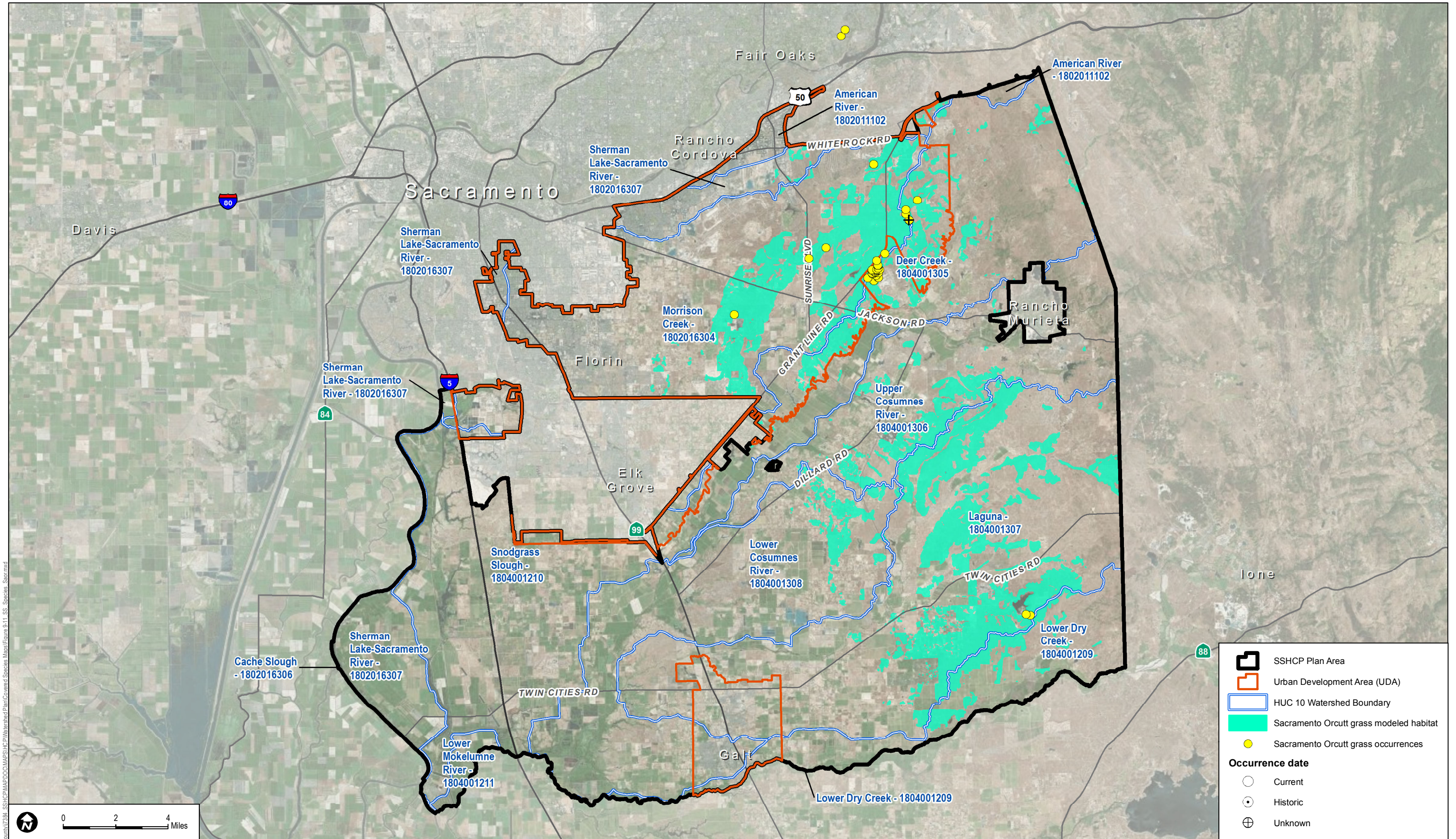
FIGURE 9-9
Legenere Modeled Habitat and Known Occurrences

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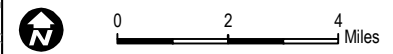


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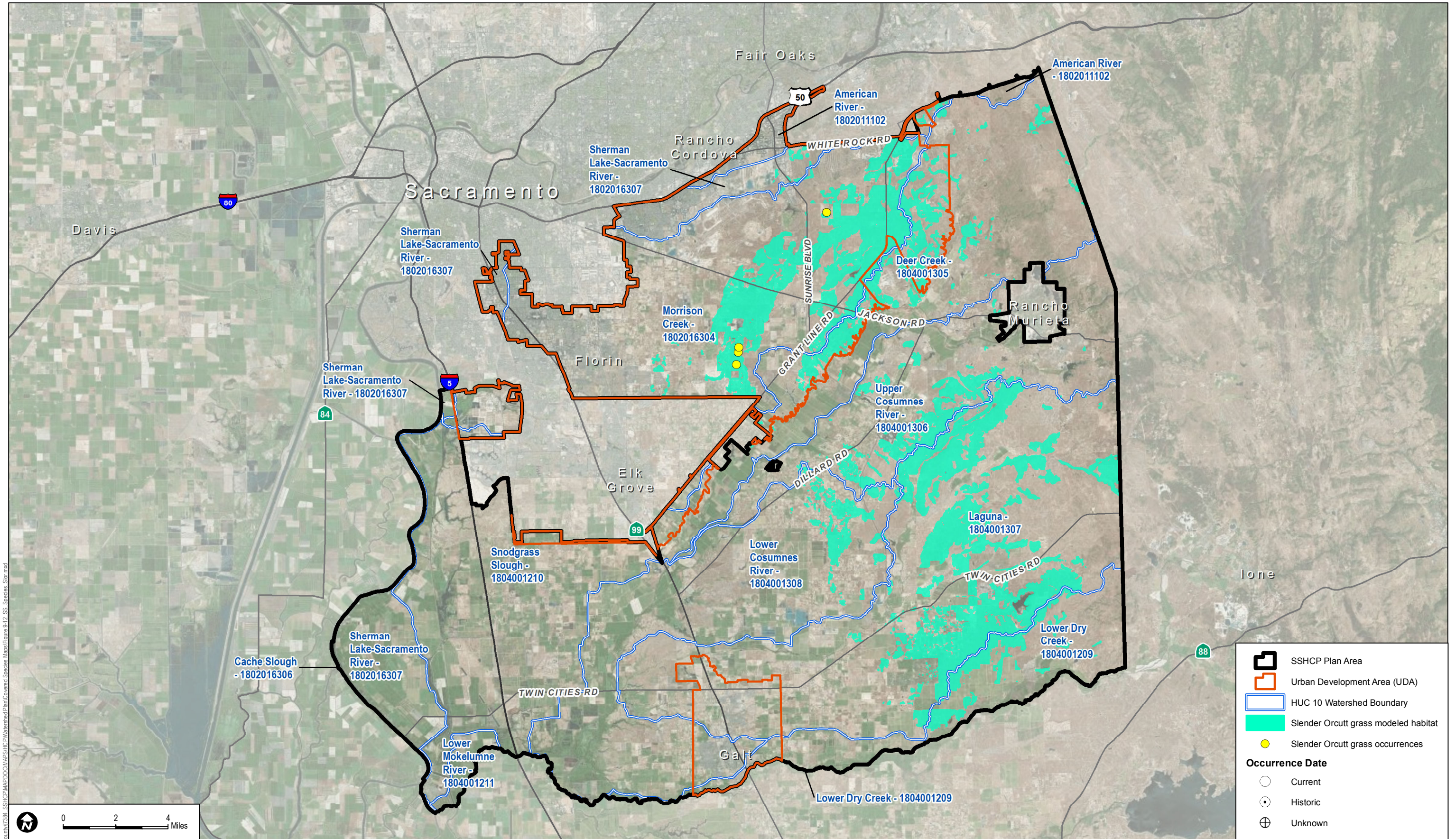
SOURCE: Bing Maps, County of Sacramento 2012, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

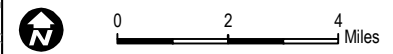
FIGURE 9-11
Sacramento Orcutt Grass Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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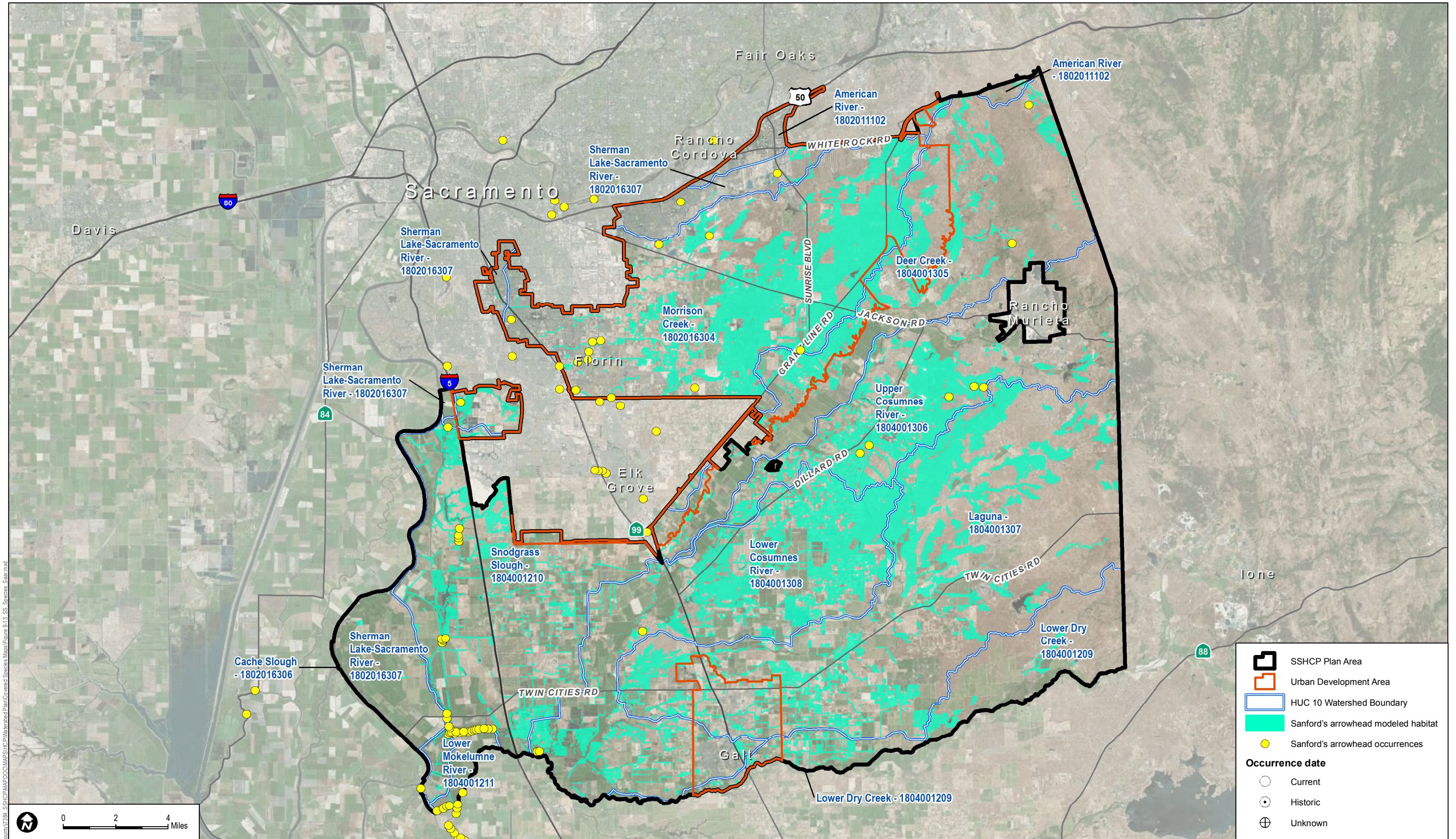
SOURCE: Bing Maps, County of Sacramento 2012, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

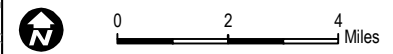
FIGURE 9-12
Slender Orcutt Grass Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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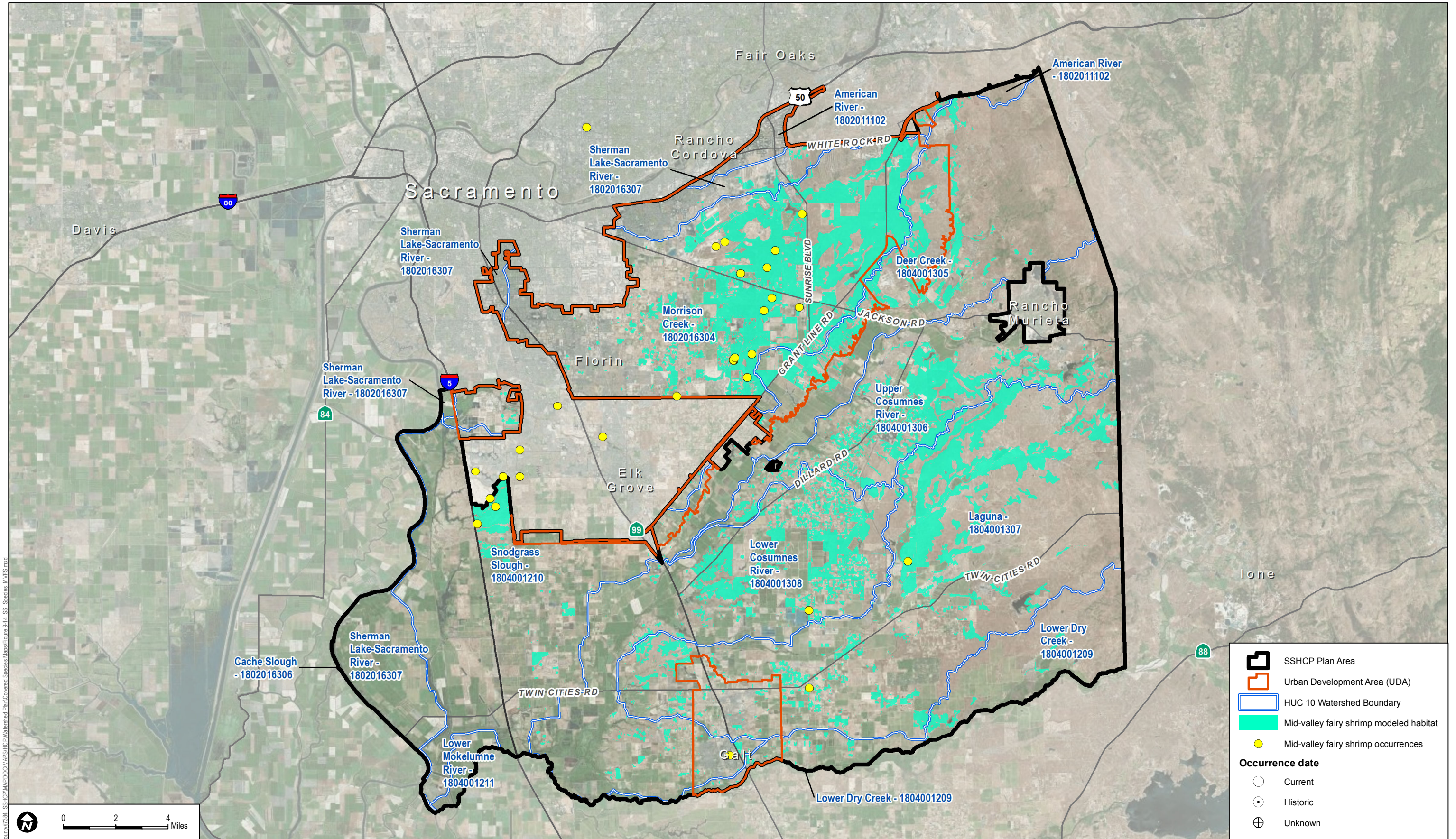
SOURCE: Bing Maps, County of Sacramento 2012, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-13
Sanford's Arrowhead Modeled Habitat and Known Occurrences

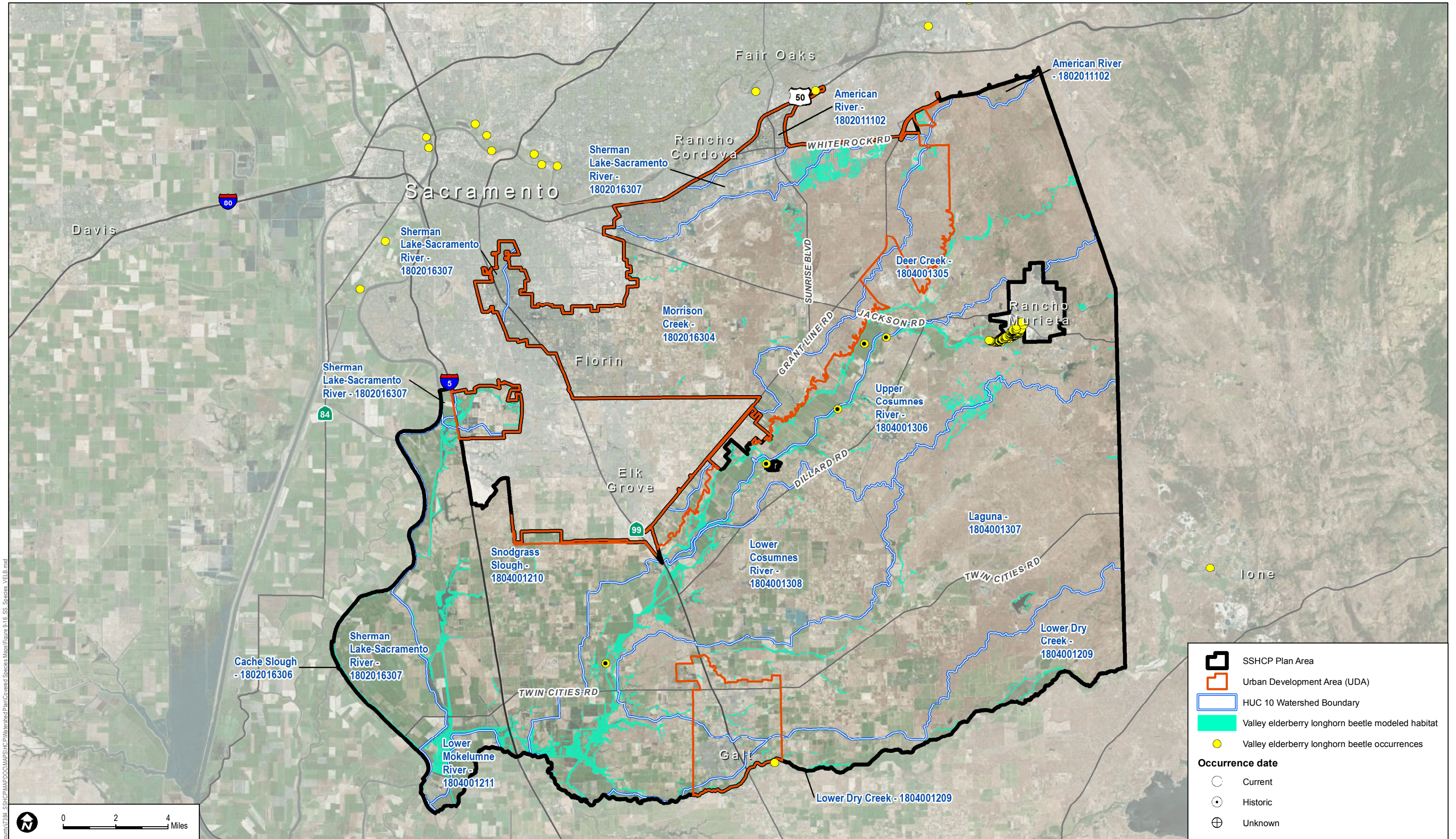
NOTE: Historic occurrences are observations prior to 1990. CNDDB points are centroids of CNDDB polygons of variable certainty.

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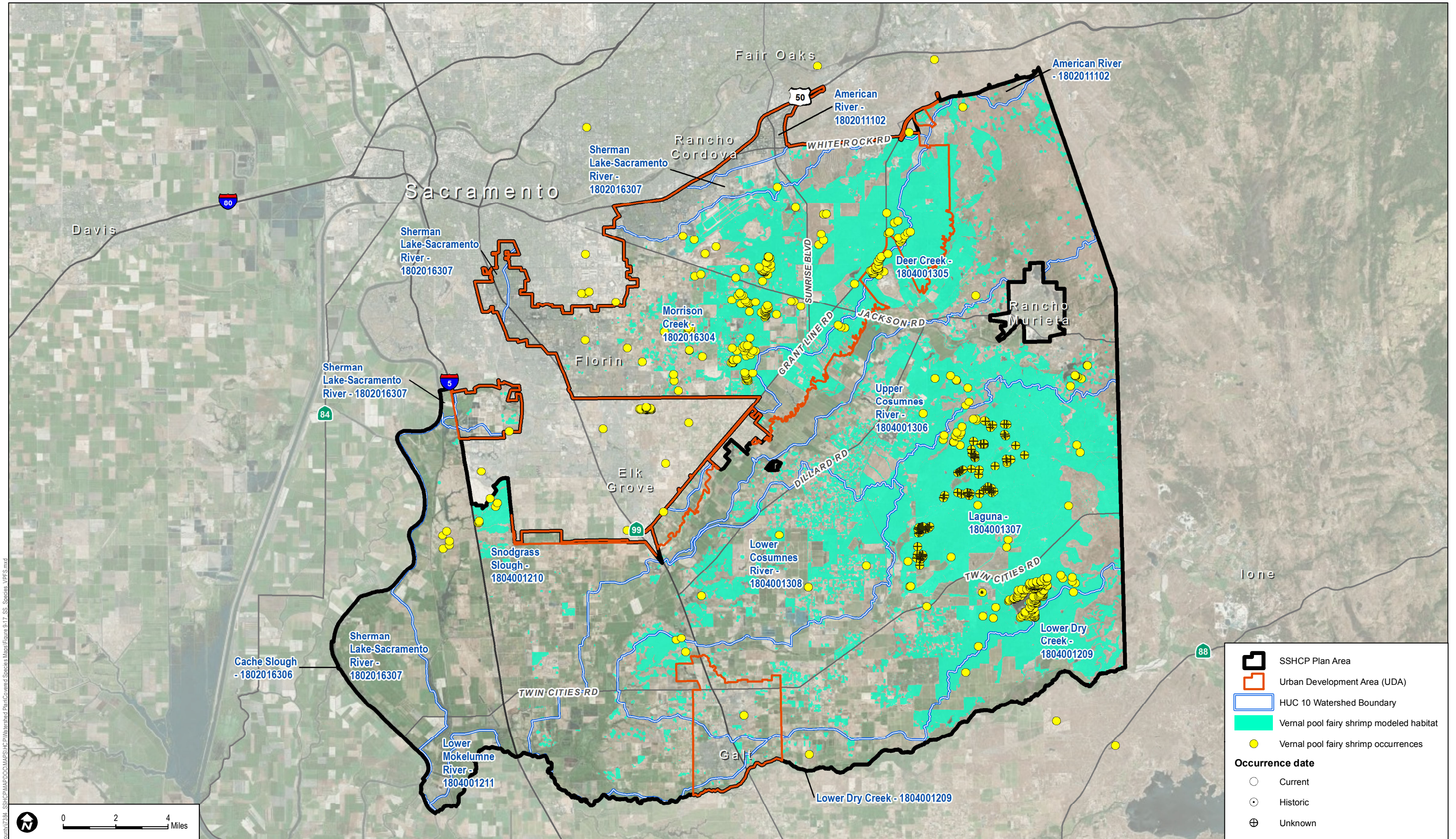


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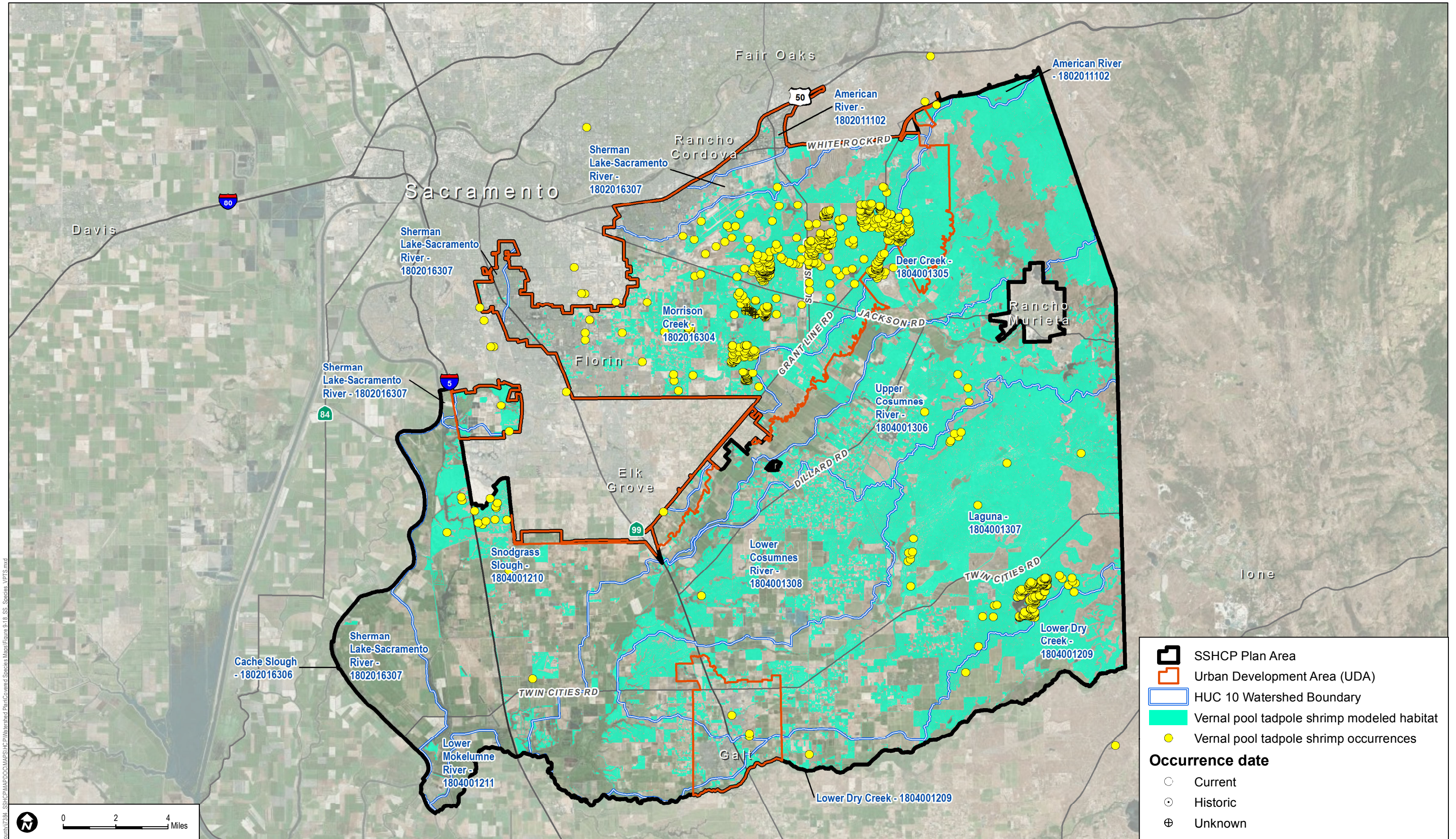
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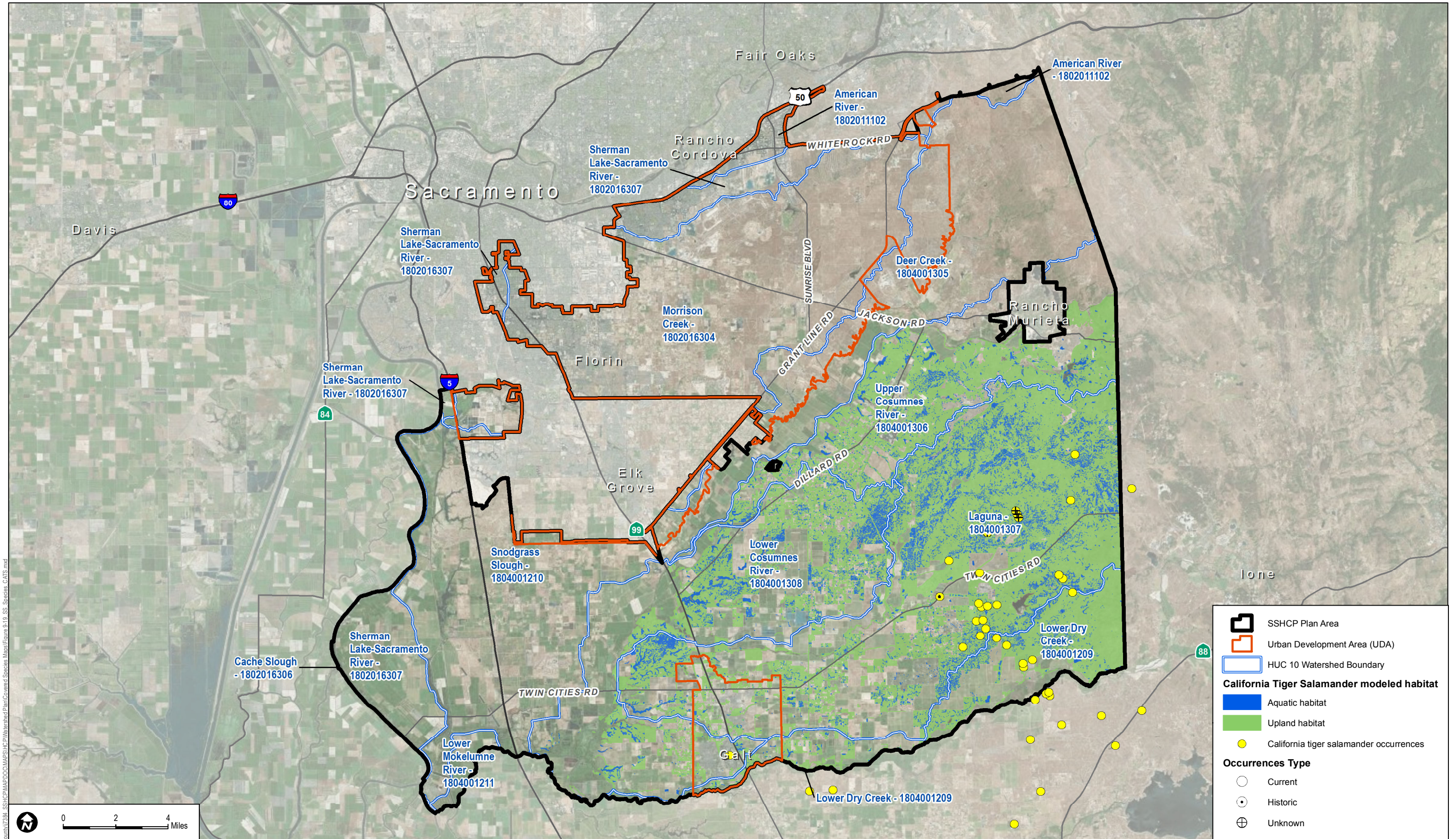
SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, C. Witham 2011, C. Little 2011, ECORP 2012, EcoAnalysts 2008, Foothill Associates 2011, Gibson & Skordal 2011, Helm 2011, Richard Hill 1999, Sugnet & Associated 1997, Kassiss-Sylva 2011, Kiefer 2011, LSA 2009, USFWS 2014, Vollmar 2011, Wildlands 2010, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-18
Vernal Pool Tadpole Shrimp Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDB points are centroids of CNDDB polygons of variable certainty.

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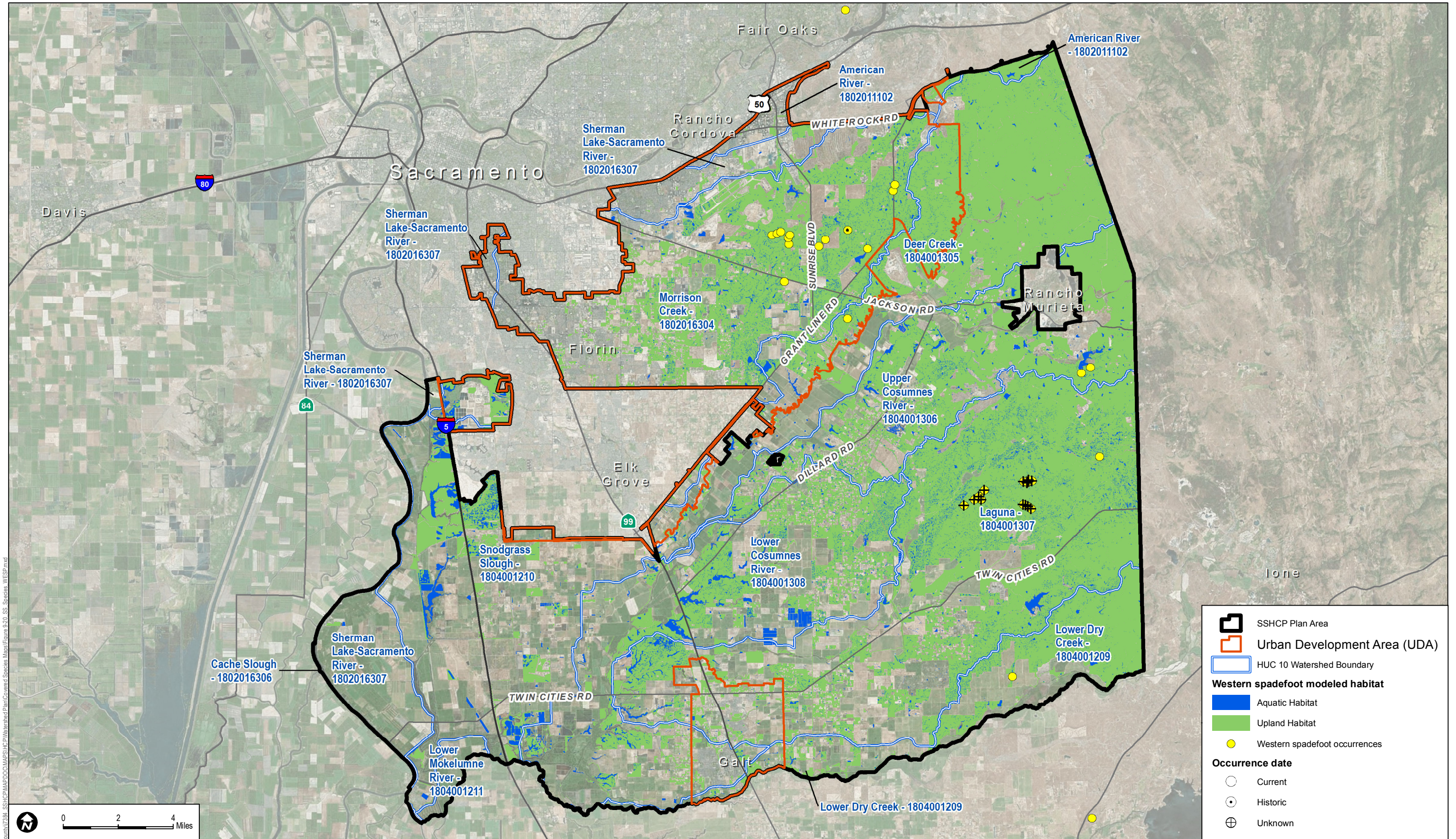
SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-19
California Tiger Salamander Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDB points are centroids of CNDDB polygons of variable certainty.

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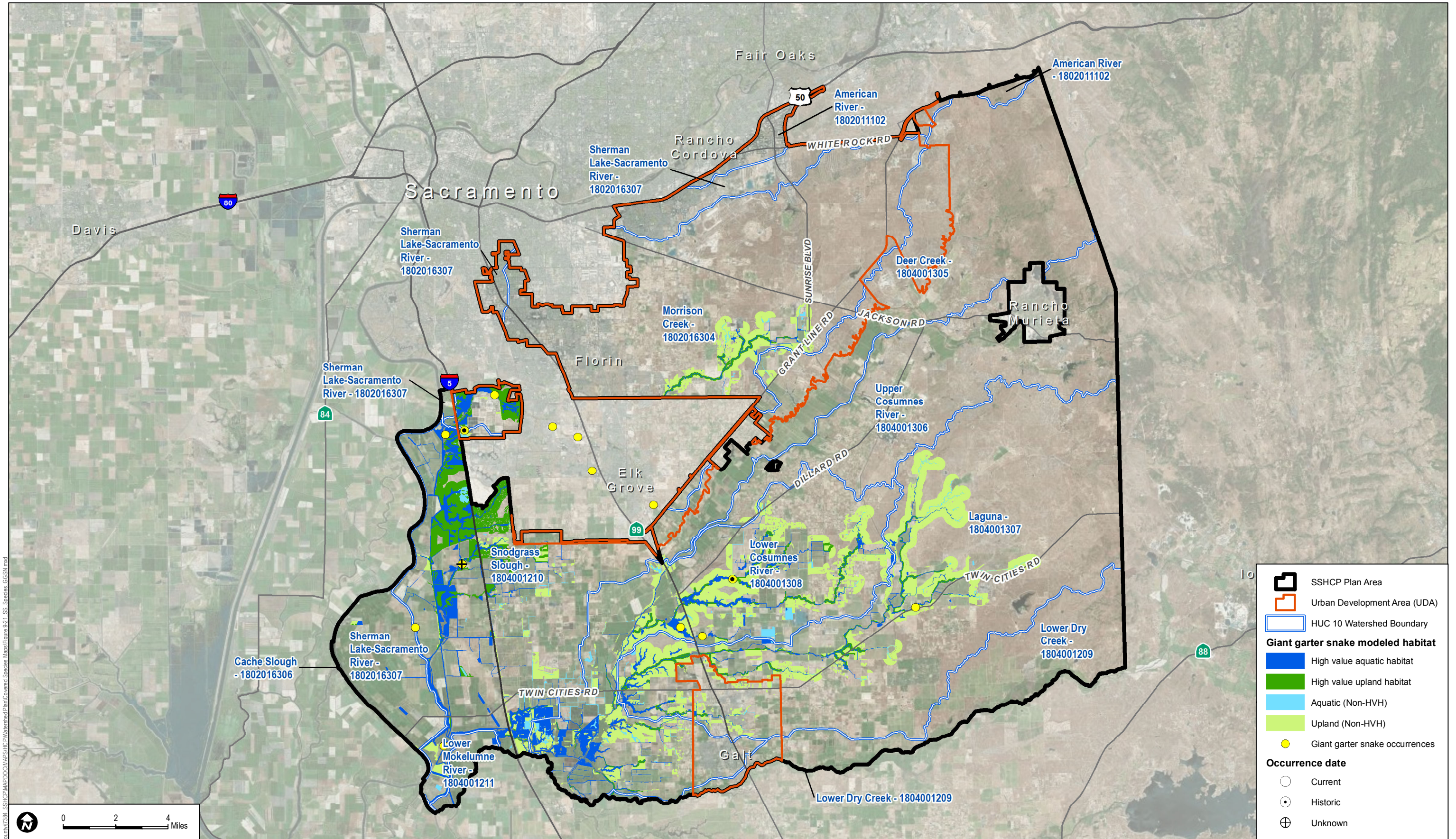
SOURCE: Bing Maps, County of Sacramento 2014, CNDDB 2012, CNPS 1999, USGS 2013 NHD

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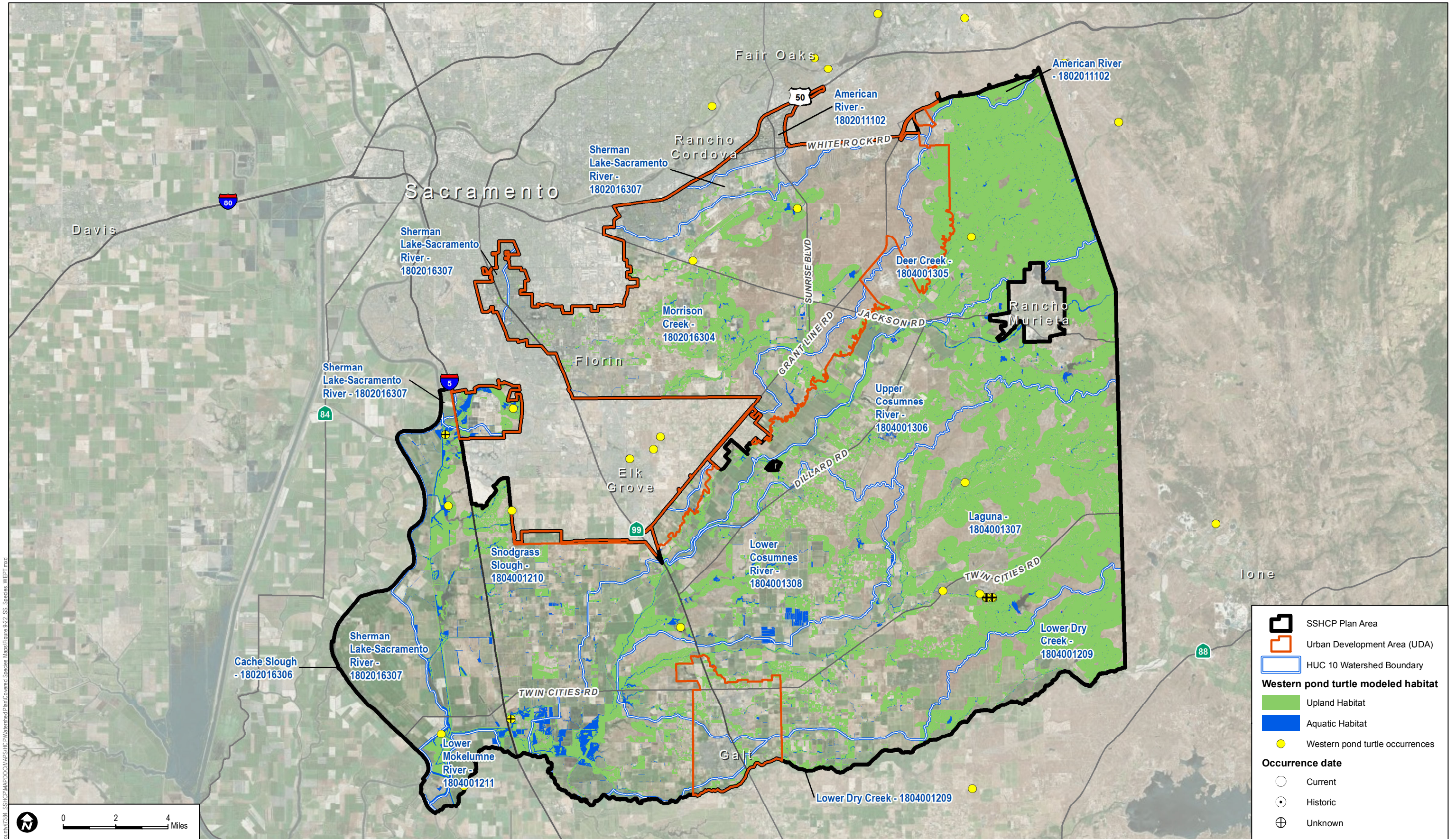
FIGURE 9-20
Western Spadefoot Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDB points are centroids of CNDDB polygons of variable certainty.

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SSHCP Plan Area

Urban Development Area (UDA)

HUC 10 Watershed Boundary

Western pond turtle modeled habitat

Upland Habitat

Aquatic Habitat

Western pond turtle occurrences

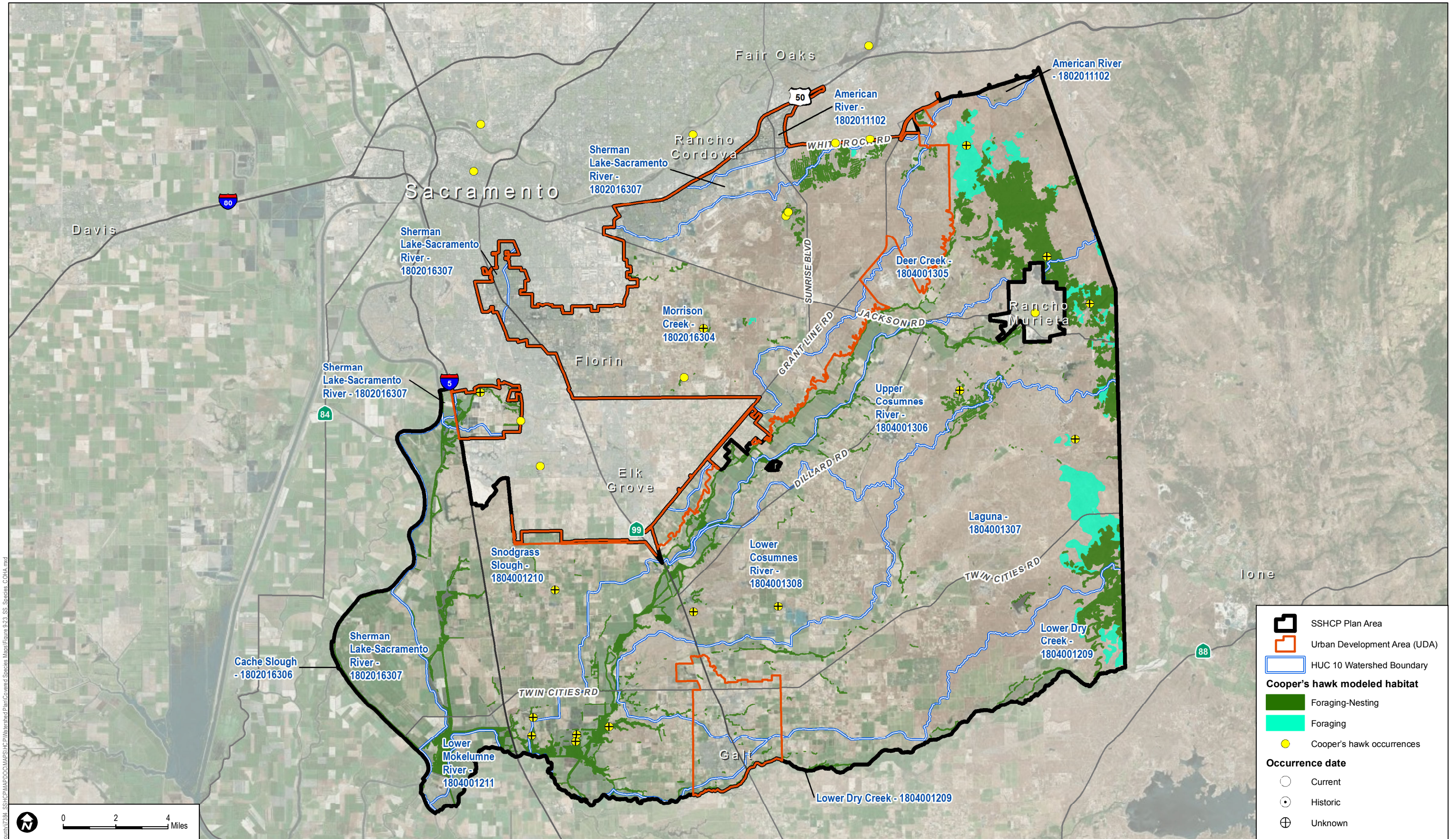
Occurrence date

Current

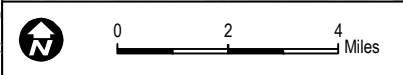
Historic

Unknown

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SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, ebird.org, USGS 2013 NHD

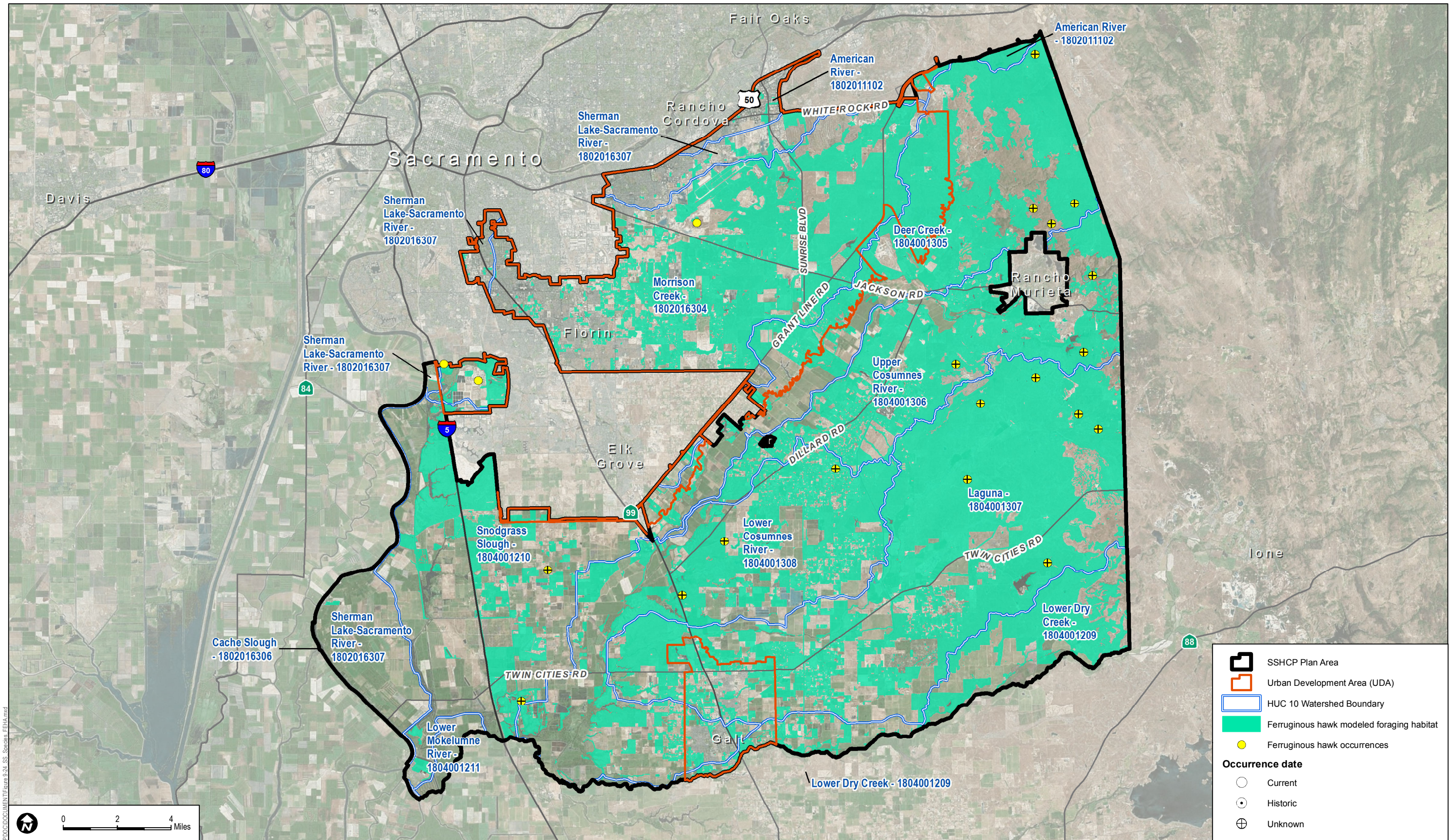
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-23
Cooper's Hawk Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDb points are centroids of CNDDb polygons of variable certainty.

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SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, ebird.org, USGS 2013 NHD

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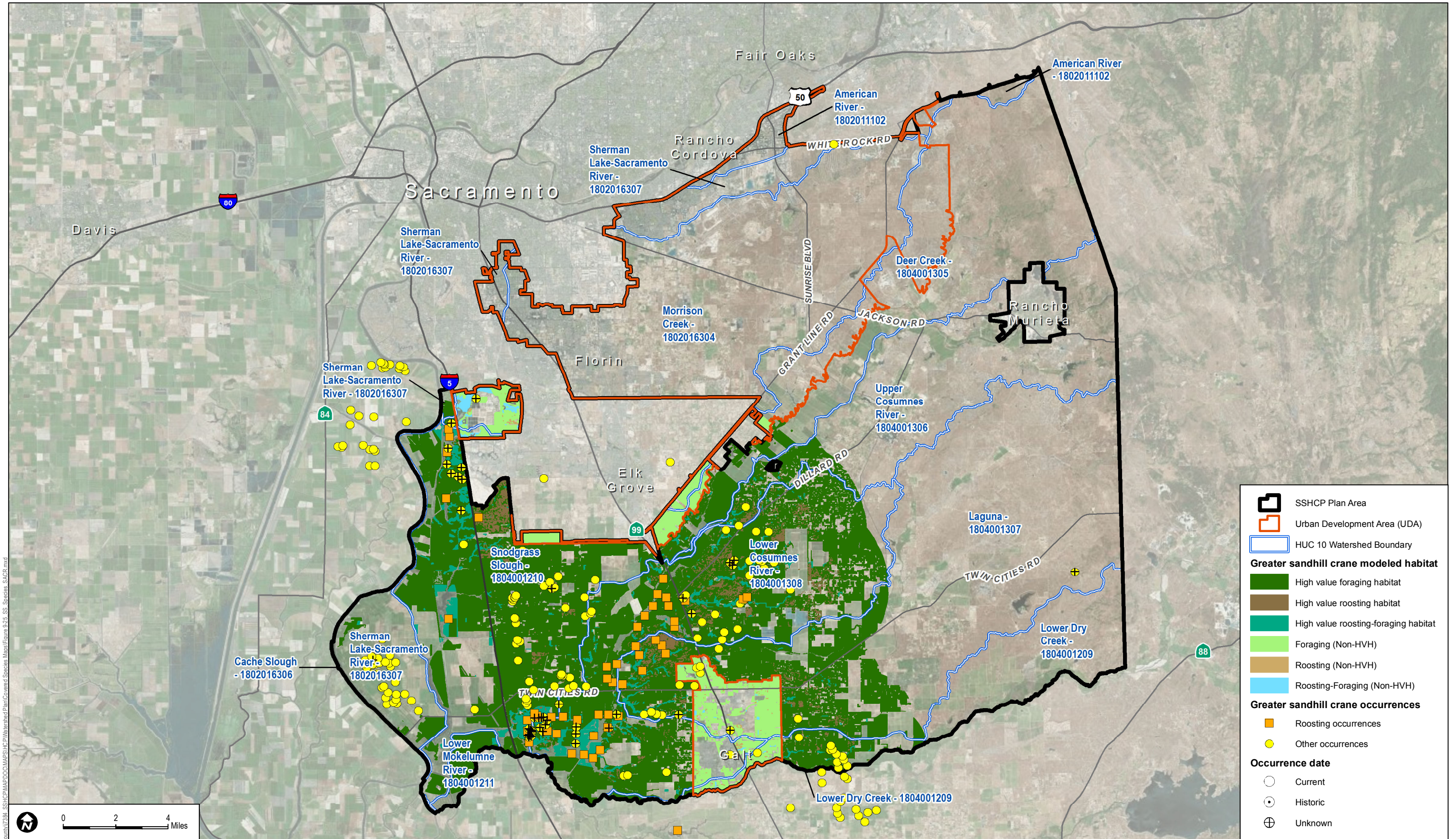
SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-24

Ferruginous Hawk Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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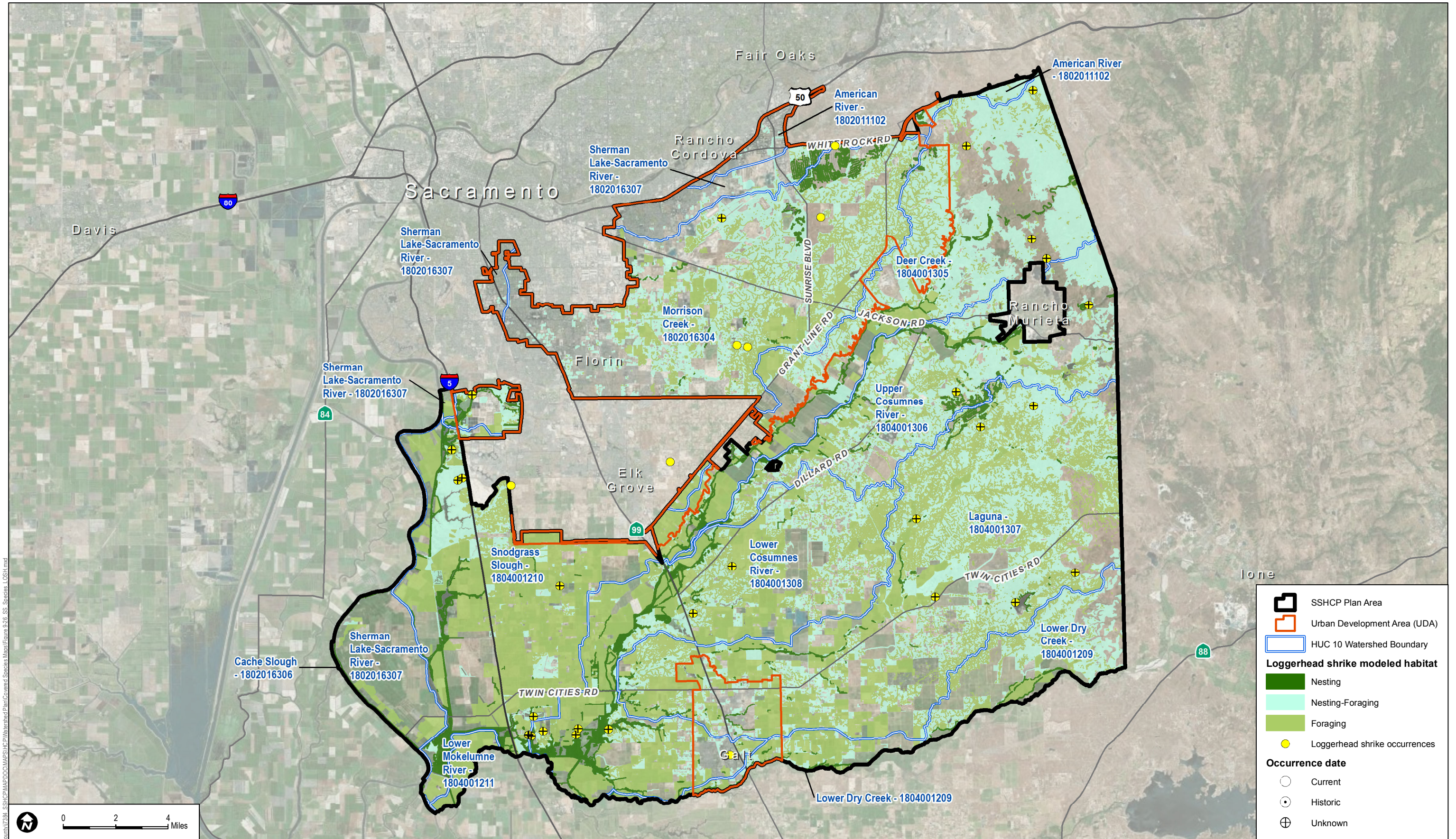


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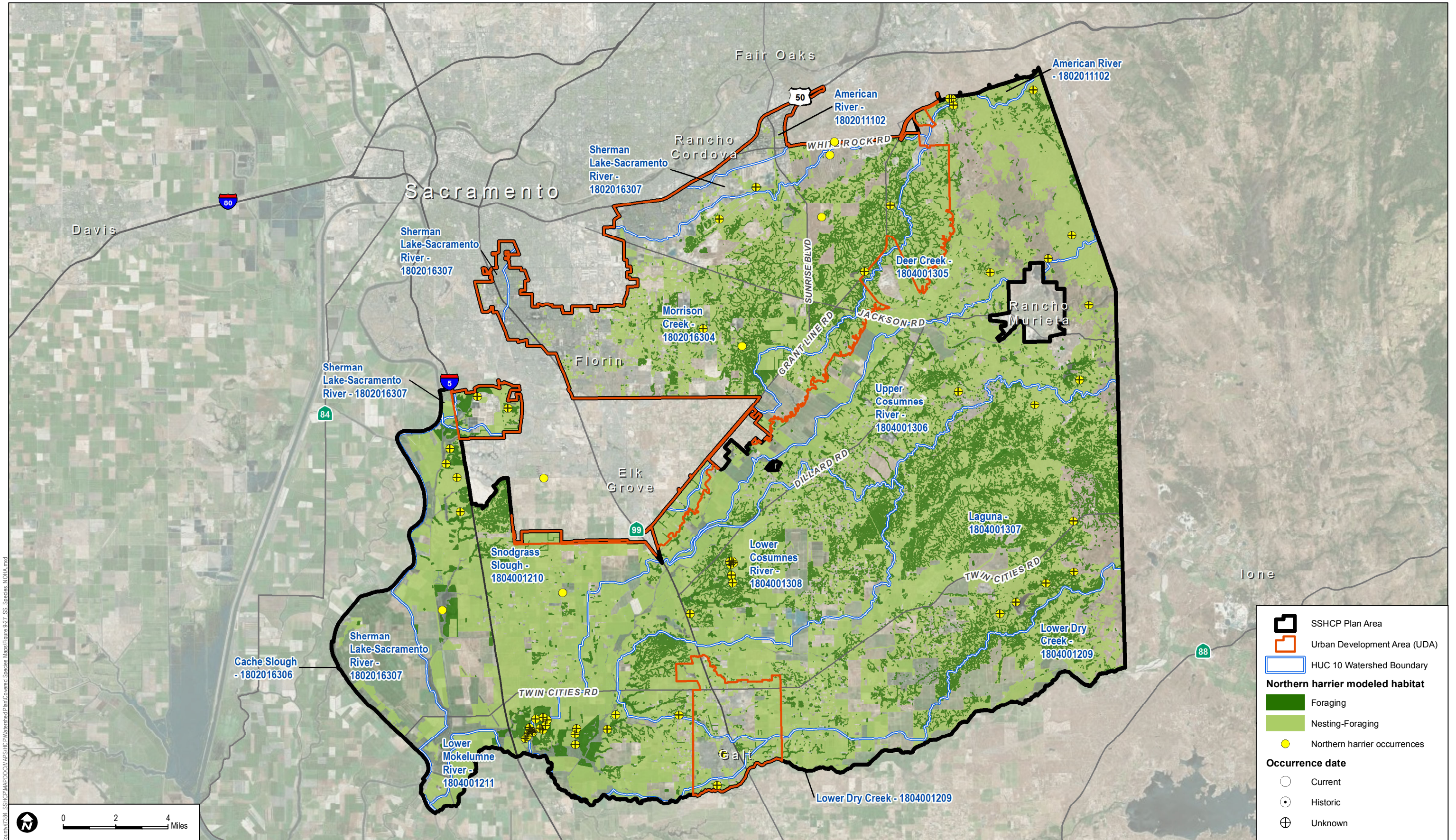
SOURCE: Bing Maps, County of Sacramento 2014, TNC 2000, Ivey 2003, Pogson & Lindstedt 2005, ebird.org, ICF 2013, USGS 2013 NHD

FIGURE 9-25
Greater Sandhill Crane Modeled Habitat and Known Occurrences
 NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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SOURCE: Bing Maps, County of Sacramento 2014, ebird.org, USGS 2013 NHD

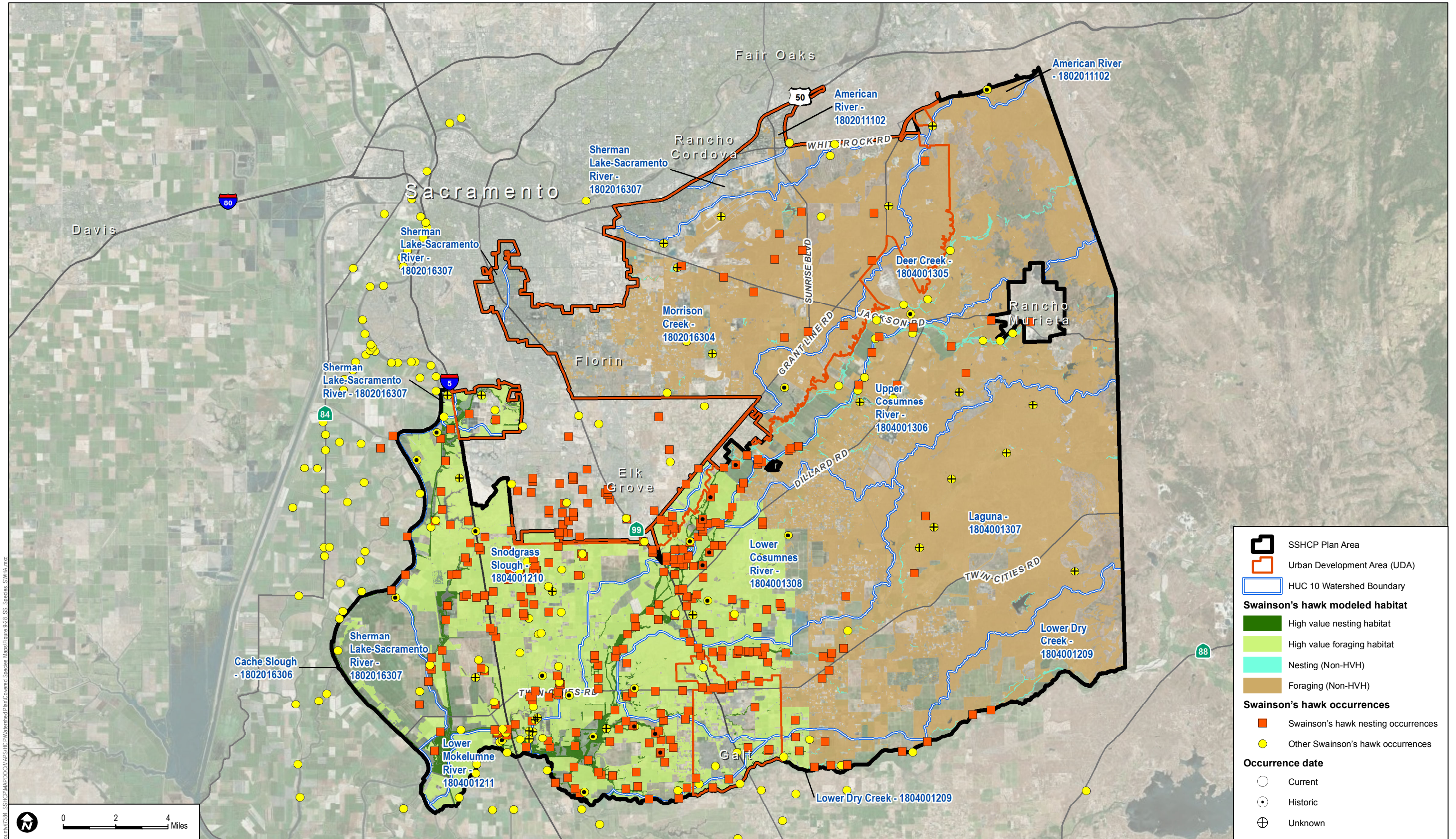
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

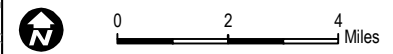
FIGURE 9-27
Northern Harrier Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, BIOS 2012, ESTEP Environmental 2006, ebird.org, USGS 2013 NHD

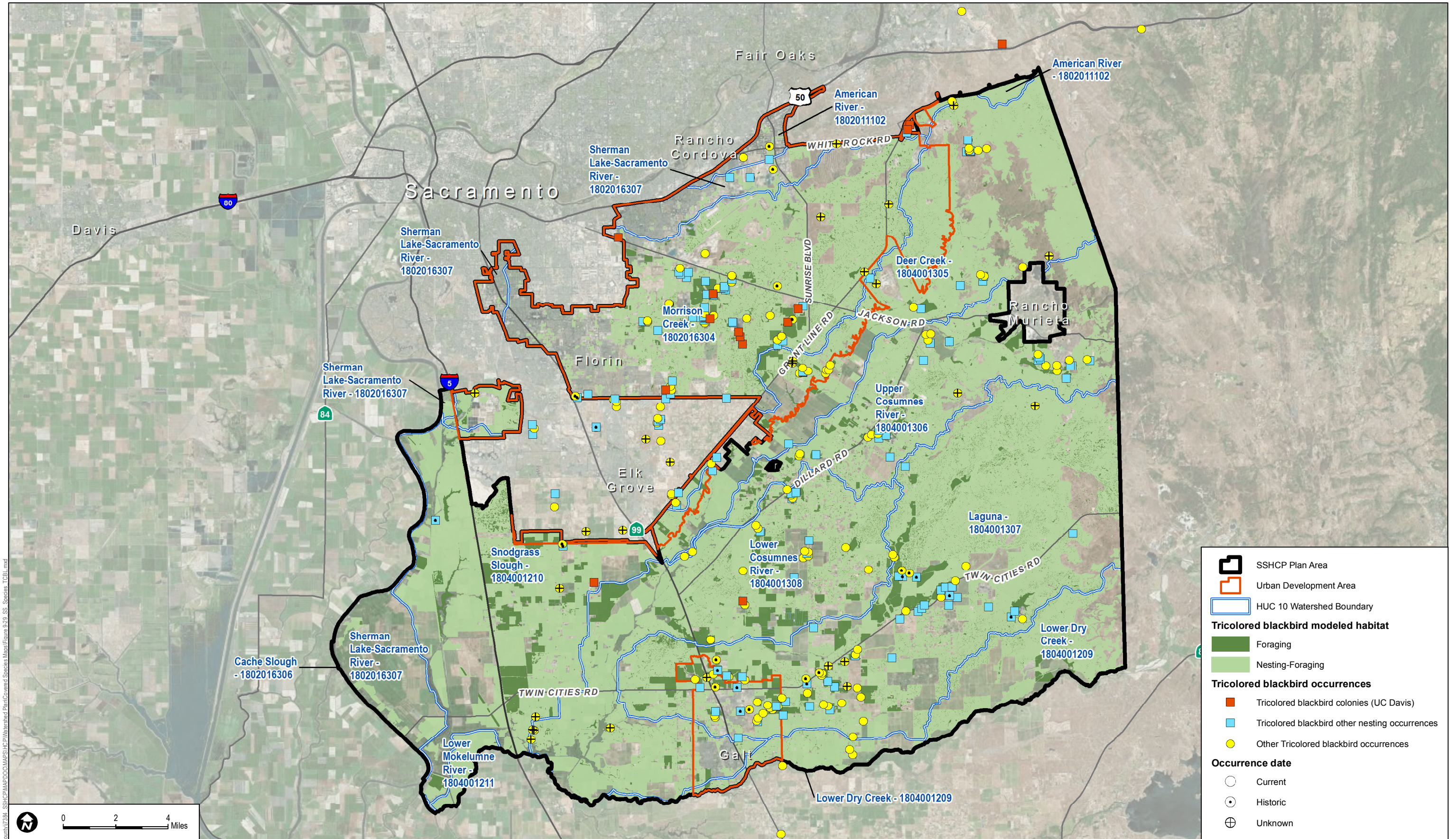
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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLANSOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-28
Swainson's Hawk Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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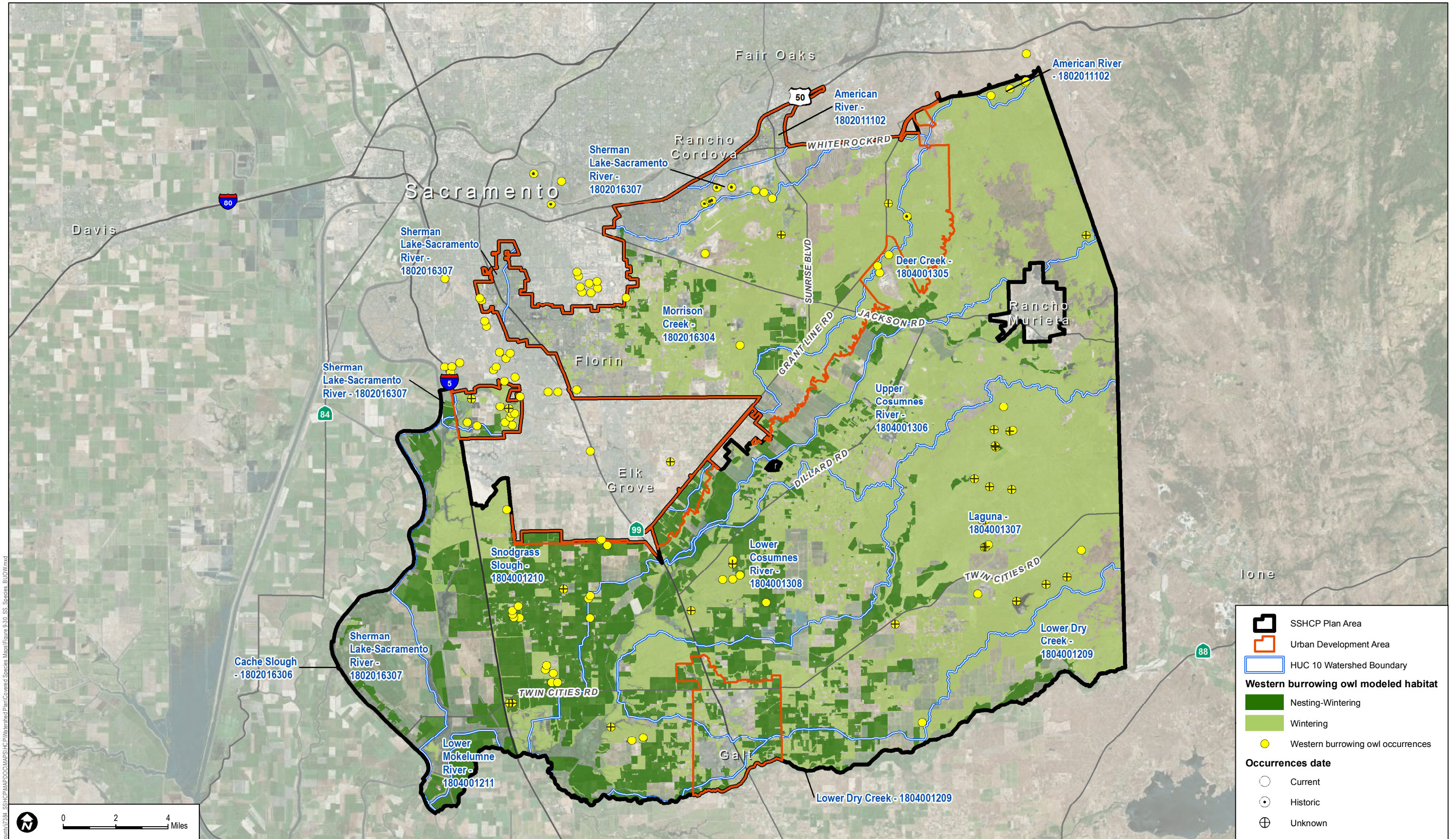
SOURCE: Bing Maps, County of Sacramento 2014, UC Davis 2014, CDFG 2012, BIOS 2012, Lizette Cook 1997, ebird.org, USGS 2013 NHD

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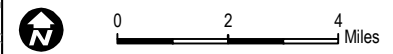
SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-29
Tricolored Blackbird Modeled Habitat and Known Occurrences

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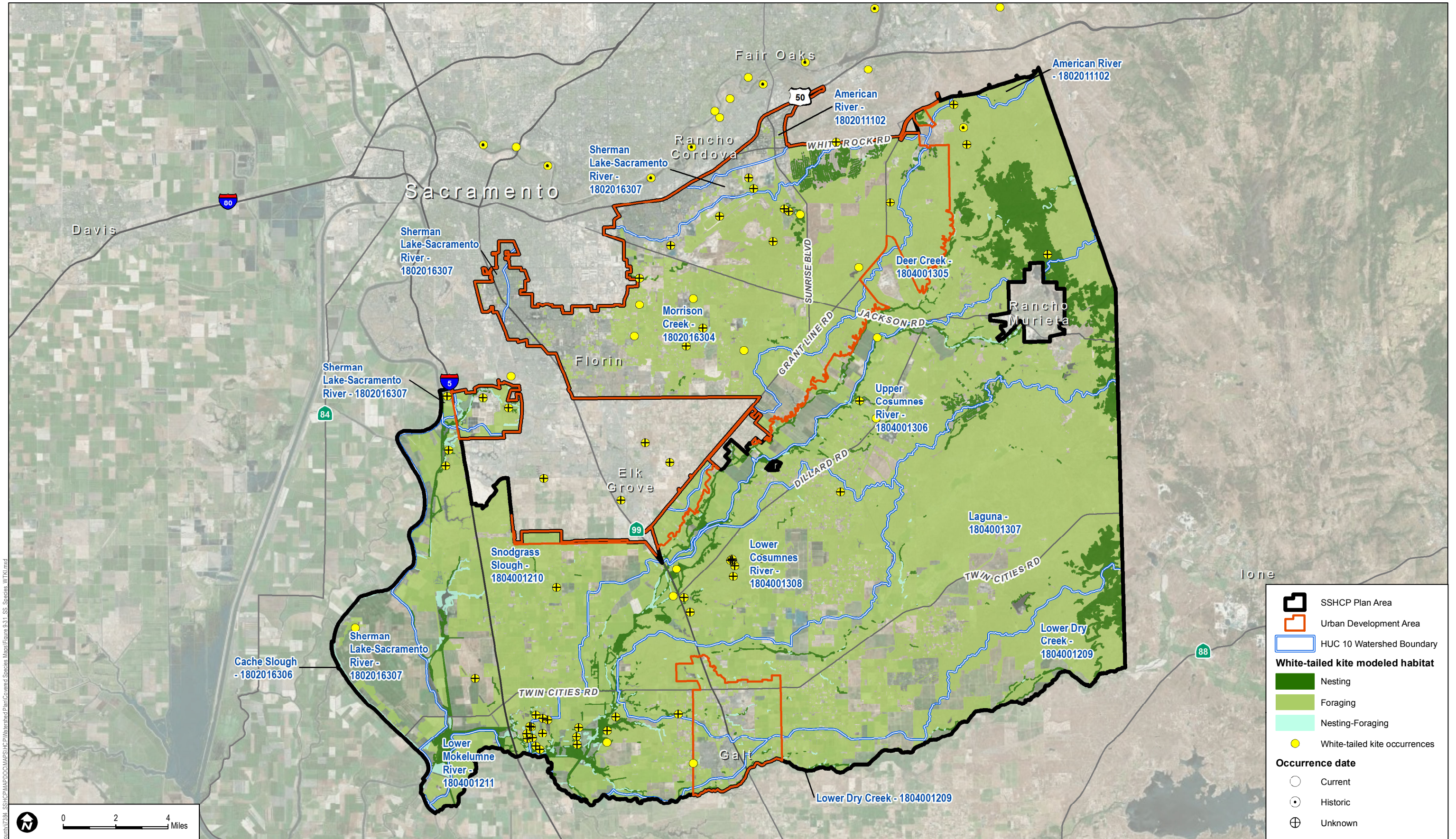
SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012,
Chris Conrad 2004, Ebird.org, TNC, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

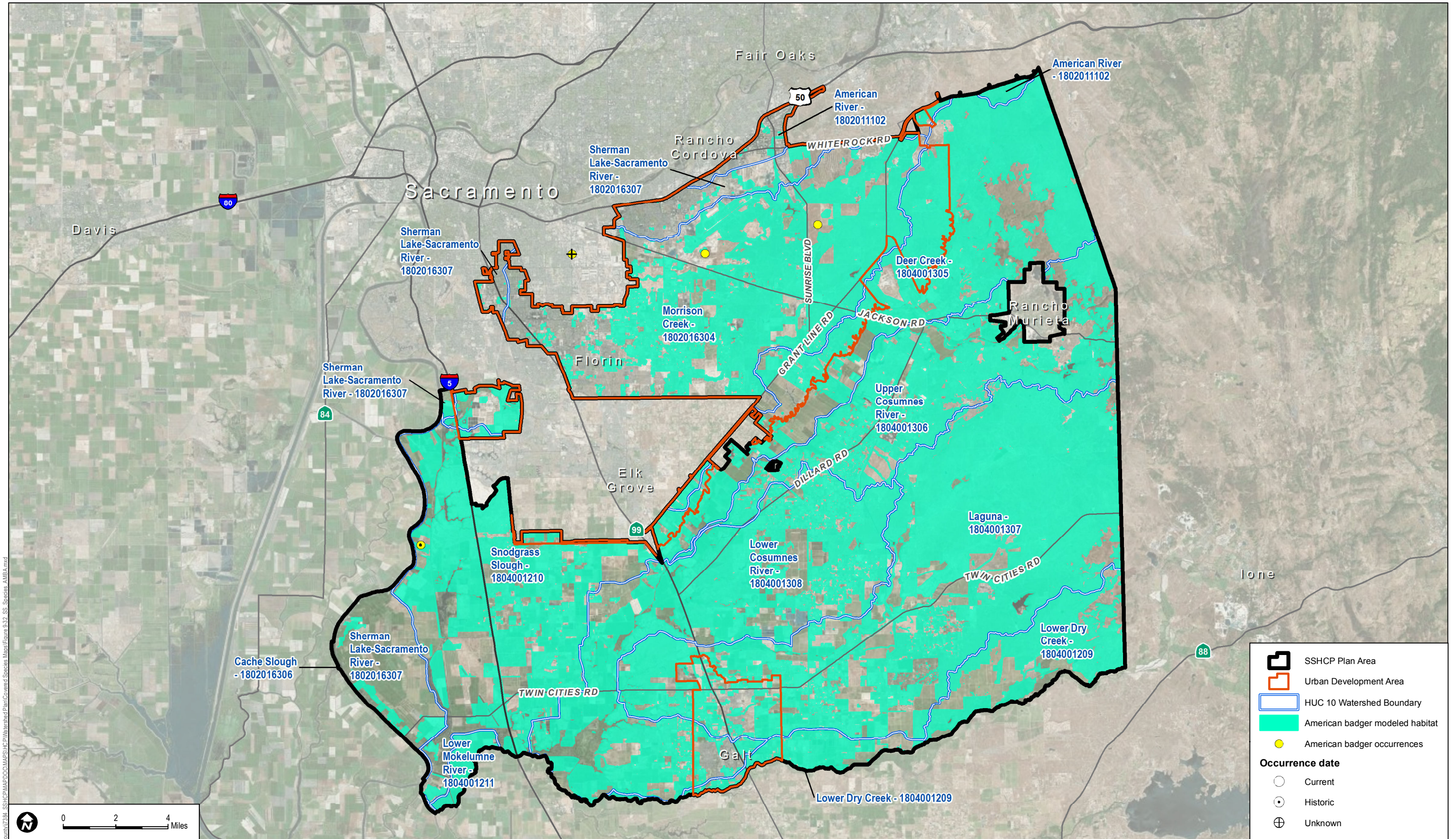
FIGURE 9-30
Western Burrowing Owl Modeled Habitat and Known Occurrences

NOTE: Historic occurrences are observations prior to 1990. CNDDDB points are centroids of CNDDDB polygons of variable certainty.

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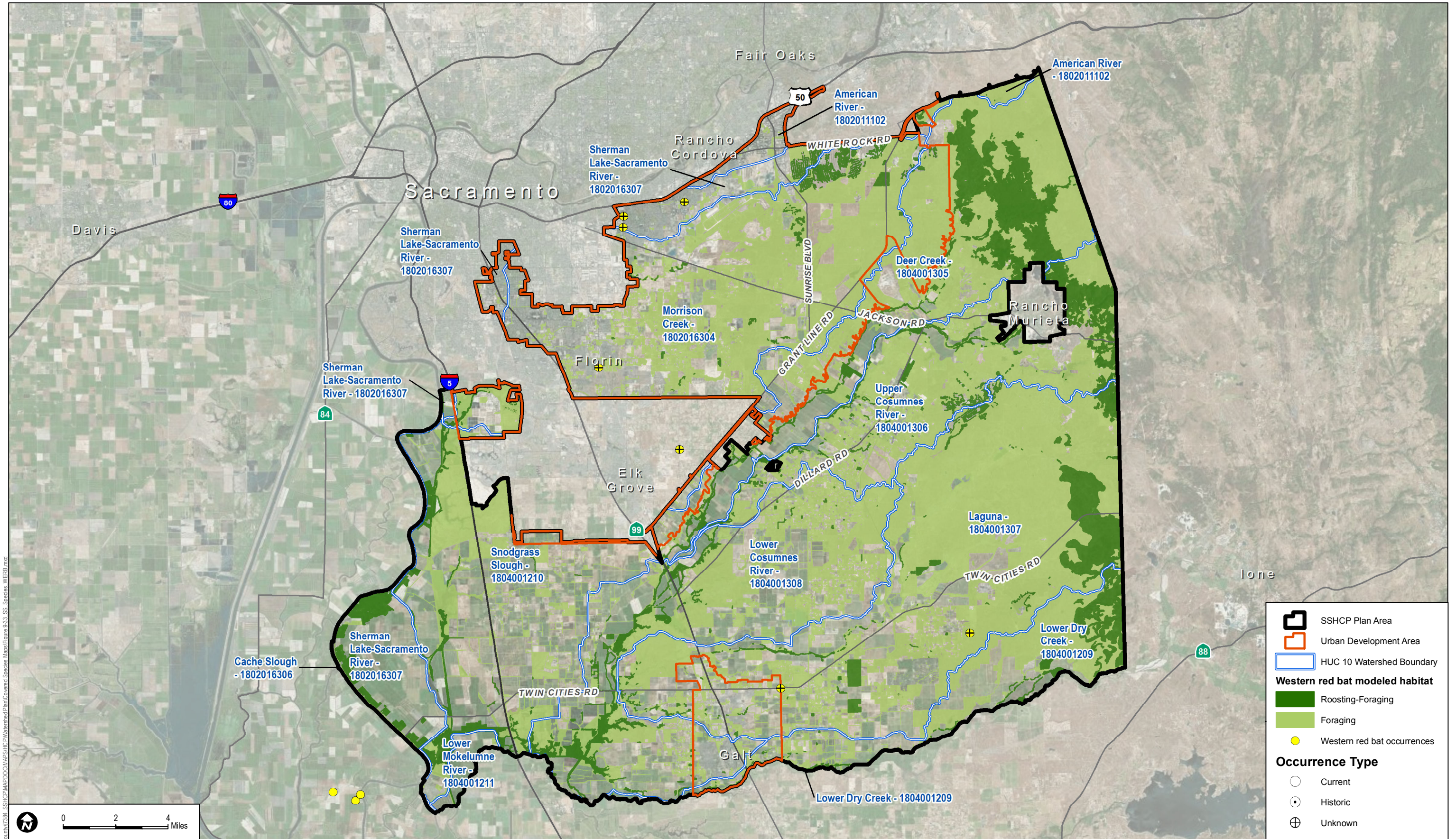
SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, USGS 2013 NHD

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SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-32
American Badger Modeled Habitat and Known Occurrences

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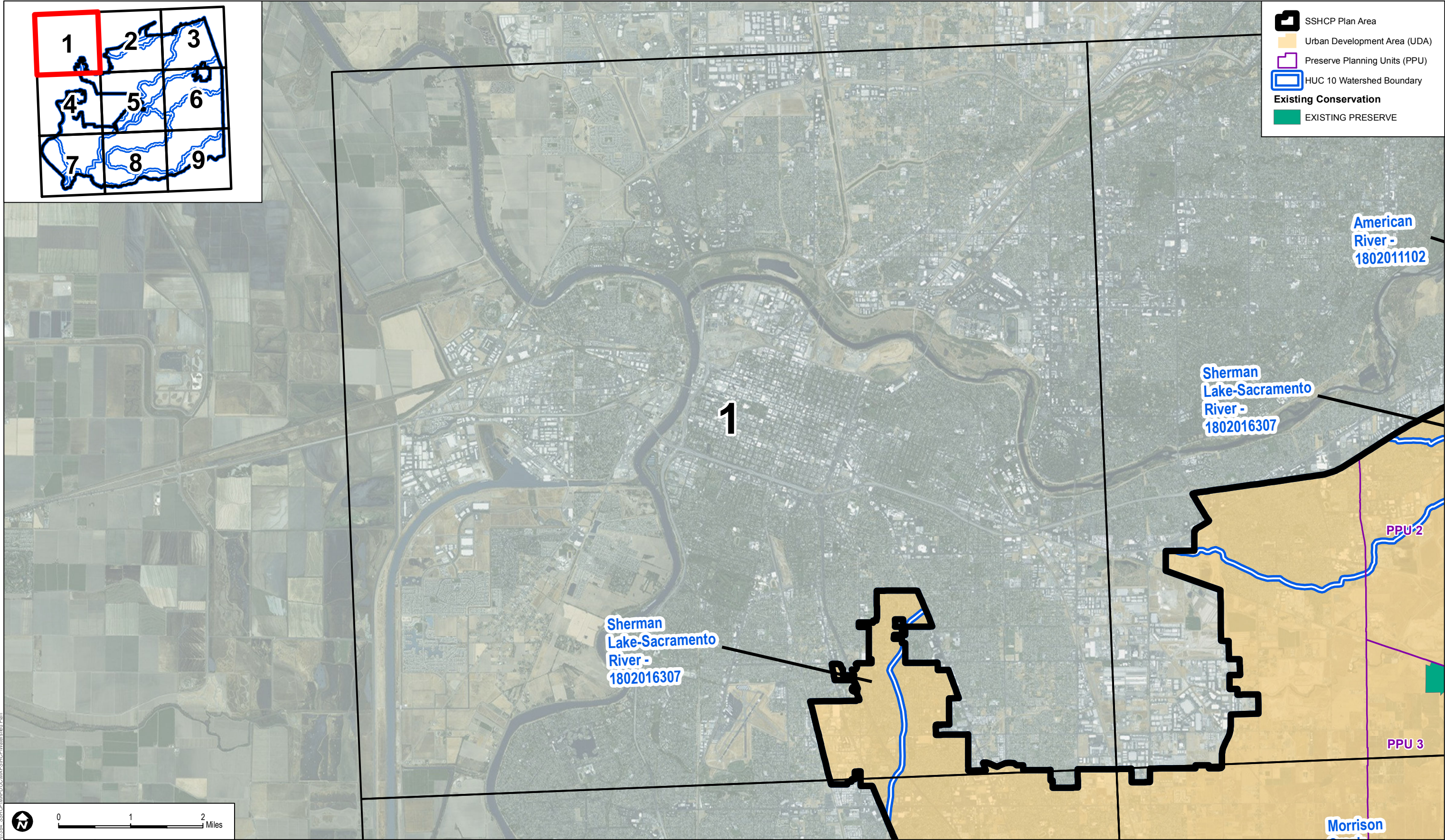
DUDEK

SOURCE: Bing Maps, County of Sacramento 2014, CDFG 2012, USGS 2013 NHD

SOUTH SACRAMENTO COUNTY HABITAT CONSERVATION PLAN WATERSHED PLAN

FIGURE 9-33
Western Red Bat Modeled Habitat and Known Occurrences

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APPENDIX B-1

Vernal Pool Classifications

APPENDIX B-1

Vernal Pool Classifications

1 DESCRIPTION OF VERNAL POOLS AND VERNAL POOL COMPLEXES

California vernal pools are a type of seasonal wetland habitat that is characterized by a specific set of physical parameters and a unique assemblage of highly specialized endemic plants and animals. Owing in part to significant loss of this habitat type in the State since the latter part of the 19th century, a number of vernal pool-dependent species are now listed as rare, threatened, or endangered with State and Federal Agencies. California vernal pools and vernal pool complexes have received considerable research attention since first recognition of their unique biota and ecological characteristics in the early 20th century (Stone 1990). Excellent sources of information exist today as a result of numerous scientific investigations, many of which are included or otherwise referenced in published proceedings of four symposia convened over the last 25 years (Jain 1976; Jain and Moyle 1984; Ikeda and Schlising 1990; Witham 1998). Consultant-produced reports pertaining to vernal pool ecology and landscape-scale conservation include Jones and Stokes (1990) and Vollmar (2002). An overview of California vernal pool ecology and biogeography can be found at http://www.maphost.dfg.ca.gov/wetlands/vp_asses_rept.

The following account provides an overview of vernal pool ecology and conservation as they pertain to analysis and planning needs for the approximately 344,600-acre SSHCP Study Area¹. As landscape-scale conservation requires, emphasis is placed on the relationships between vernal pool habitat (climate, geology, soils, hydrology, and disturbance) and the associated assemblage of vernal pool-dependent plants and animals, including the 13 species covered by the SSHCP (Table B1-1).

Table B1-1
Vernal Pool Species Covered under the
South Sacramento County Habitat Conservation Plan

Group	Status ²	General Distribution By County or Region ³	Habitat Associaton ⁴
Common Name Scientific Name			
Plants			
Ahart's dwarf rush <i>Juncus leiospermus</i> var. <i>ahartii</i>	CNPS 1B	Butte, Calaveras, Placer, Sacramento, Yuba	Shallow vernal pools and margins of large pools; 98-328 feet; March-June
Boggs Lake hedge-hyssop <i>Gratiola heterosepala</i>	SE, CNPS 1B	Fresno, Lake, Lassen, Madera, Merced, Modoc, Placer, Sacramento, Shasta, Siskiyou, San Joaquin, Solano, Tehama; Oregon	"Larger" vernal pools, vernal marshes and swamps; 33-7,792 feet; March- August

¹ The "SSHCP Study Area" differs from the "Plan Area" as described in the main body of the SSHCP due to the Sphere of Influence (SOI) boundary changes and the inclusion of the area west of Interstate 5 in the southern portion of the County.

APPENDIX B-1 (Continued)

Table B1-1
Vernal Pool Species Covered under the
South Sacramento County Habitat Conservation Plan

Group	Status ²	General Distribution By County or Region ³	Habitat Association ⁴
Common Name Scientific Name			
Dwarf downingia <i>Downingia pusilla</i>	CNPS 2	Merced, Mariposa, Napa, Placer, Solano, Sacramento, Sonoma, Stanislaus, Tehama, Yuba; South America	Small to medium vernal pools and swales; 3.3-1,450 feet; March-May
Legenere <i>Legenere limosa</i>	CNPS 1B	Lake, Napa, Placer, Sacramento, Shasta, San Mateo, Solano, Sonoma*, Stanislaus*, Tehama	"Larger/deeper" vernal pools; 3.3-2,887 feet; April-June
Pincushion navarretia <i>Navarretia myersii</i> spp. <i>myersii</i>	CNPS 1B	Amador, Lake, Merced, Sacramento	Small to medium size vernal pools; 66-1,083 feet; April-May
Sacramento Orcutt grass <i>Orcuttia viscida</i>	SE, FE, CNPS 1B	Sacramento	"Larger/deeper" vernal pools; 98-328 feet; April-July
Slender Orcutt grass <i>Orcuttia tenuis</i>	SE, FT, CNPS 1B	Lake, Lassen, Plumas, Sacramento, Shasta, Siskiyou, Tehama	"Larger/deeper" vernal pools; 115-5,775 feet; May-October
<i>Invertebrates</i>			
Mid-valley fairy shrimp <i>Branchinecta mesoamericana</i>	FSC	Southern Sacramento County, west to Solano and Contra Costa County, along east side of the Central Valley south to Fresno County	Small to medium vernal pools, rarely vernal swales.
Ricksecker's Water Scavenger Beetle <i>Hydrochara rickseckeri</i>	FSC	Alameda, Marin, Placer, Sacramento, San Mateo, Sonoma	Vernal pools and seasonal wetlands.
Vernal pool fairy shrimp <i>Branchinecta lynchi</i>	FT	Central Valley, central and southern Coast Ranges, southern Oregon	Small to medium vernal pools, occasionally vernal swales.
Vernal pool tadpole shrimp <i>Lepidurus packardii</i>	FE	Central Valley from Shasta County to northern Tulare County; endemic to Central Valley	Medium to large vernal pools.
<i>Amphibians</i>			
California tiger salamander <i>Ambystoma californiense</i>	ST, FT	Central Valley and Coast Range, from Sonoma to Santa Barbara County	Breeds in vernal pools and ponds; restricted to rodent burrows during dry months.
Western spadefoot <i>Spea hammondi</i>	SSC, FSC	Central Valley and Coast Range from eastern Alameda County to northwest Baja California; Mexico	Breeds in vernal pools and ponds, aestivates during dry months in self-made burrows.

Notes:

1. Data compiled from the California Native Plant Society's Inventory of Rare and Endangered Plants of California (2001), and USFWS Federal Register (1994, 1997, 2004a, 2004b).
2. FE: federal endangered; FT: federal threatened; FSC: federal species of concern; SE: state endangered; SSC: state species of concern; CNPS Lists= List 1B: rare, threatened or endangered in California and elsewhere; List 2: rare, threatened or endangered in California, but more common elsewhere.
3. Asterisks represent recorded extirpations.
4. Flowering periods are given for plants in this column.

1.1 Vernal Pool Habitat, Climate, Landforms, Geologic Formations and Soils

The vernal pool complexes of California are considered to be relatively recent ecological entities, having evolved in the Central Valley landscape after the inland Tertiary-Age sea receded, the late Pleistocene lakes dried, and the present-day Mediterranean-type climate fully developed (Stone 1990; Stebbins 1976; Raven and Axlerod 1978). The vernal pool ecosystem developed and persists as a result of complex relationships between this climate, the region's geology and soils, the vernal pool hydrological cycle, and biological, ecological, and evolutionary processes (Keeley and Zedler 1998; Stone 1990; Holland and Dains 1990).

The annual hydrological cycle that defines the vernal pool wetland ecosystem is driven by the predictable cool wet winters and warm, extremely dry summers that characterize the Mediterranean-type climate of California. In the context of this seasonal regime, vernal pools develop in depressional basins on substrates possessing an impermeable layer that restricts the downward percolation of water through the soil profile. In general, vernal pools are classified by the nature of the water impediment as being hardpan, claypan, or volcanic mudflow-type vernal pools (Holland 1978, 1986; Sawyer and Keeler-Wolf 1995).

Different geologic formations and their associated soils exhibit different propensities for the development of vernal pools (Keeley and Zedler 1998; Holland and Dains 1990; Metz 2001). Further, vernal pools and vernal pool complexes can differ in fundamental physical and biological ways between geologic formations in a given region (Holland and Dains 1990; Smith and Verrill 1998; Platenkamp 1998; Metz 2001; Vollmer 2002; Helm and Vollmar 2002; Laabs et al. 2002; Dittes and Guardino 2002). In addition to landform-specific variance in the soil substrate itself (e.g., particle size fraction, chemistry, depth to hardpan, water retaining capacity, etc.), sub-watershed drainage area, pool size, shape, ponding depth, ponding duration, soil dry-down rates and other hydrological dynamics appear to be related to Geologic Formation (Metz 2001; Smith and Verrill 1998; Hobson and Dahlgren 1998).

Particular geologic formations possess specific biogeographic legacies (e.g., ages, centers of evolutionary origin and diversification, available refugia during long-term extreme climatic cycles, anthropological land management history, etc.); these being reflected in present day patterns of biodiversity (Holland and Dains 1990; Dittes and Guardino 2002).

In the SSHCP Study Area, 18 different geologic formations support vernal wetlands. These geologic formations are listed in Table B1-2 and are further described in Section 3.

APPENDIX B-1 (Continued)

Table B1-2
Summary of Landforms, Geologic Formations and Soils
in the SSHCP Study Area, with Associated Attributes

Landform	Geologic Formation	Period/Epoch	Age ² (Ma)	Parent Material/Description
Other	Metamorphic Rocks, Undifferentiated (pKu)	Pre-Cretaceous	Prior to 145	Composed of amphibolite, greenstone, vein quartz, slate, and shale.
High Terrace	Ione (Ti)	Eocene	35-55	Quartz sandstone deposited along ancient inland seashore
Mudflow/Lavaflow	Valley Spings (Tvs)	Oligocene/ Miocene	5-35	Cemented rhyolitic tuff deposited as fluvial clay, silt, and sand
Mudflow/Lavaflow	Mehrten (Tm)	Miocene / Pliocene	2-25	Moderately undurated fluvial sand, silt, and minor gravel alluvium, presumably from reworked andesitic volcanic mudflow deposits to the northeast
High Terrace	Laguna (Tl)	Late Pliocene	2	Weakly to moderately indurated granitic alluvium (sand, silt and minor gravel)
High Terrace	North Merced Gravel (Qtnm)	Late Pliocene / Early Pleistocene	1-2	Thin, locally derived pediment veneer of cobble gravel on very high terraces capping Tertiary and pre-Tertiary rocks, deposited through outwash of Sierra Nevada glaciation
High Terrace	Turlock Lake (Tpl)	Late Pliocene / Early Pleistocene	1-2	Weakly indurated granitic alluvium (sand, fine sand, minor clay and gravel)
Low Terrace	Riverbank Undivided (Qr)	Pleistocene	0.1	Interbedded granitic sand, silt and clay, with metamorphic channel gravels
Low Terrace	Riverbank, Lower Unit (Qrl)	Pleistocene	0.1	Granitic alluvium (sand, silt, clay and gravel)
Low Terrace	Riverbank, Middle Unit (Qrm)	Pleistocene	0.1	Locally and remotely derived granitic and basic igneous alluvium (sand, silt, clay and gravel)
Low Terrace	Riverbank, Upper Unit (Qru)	Pleistocene	0.1	Unconsolidated but compact dark brown to red alluvium
Low Terrace	South Fork Gravels (Qsf)	Pleistocene	0.1	Stream-rounded cobbles and gravels in a clay matrix
Other	Upper Unit Modesto (Qmu)	Upper Pleistocene / Holocene	0.01	Mixture of arkosic sand, gravel, and silt consisting of mainly quartz and feldspar.
Other	Surficial Deposits (Qu)	Holocene	recent	Unconsolidated surficial deposits from mixed alluvial sources
Other	Dredge Tailing and Artificial Fill (t)	Holocene	recent	Rows of cobble, gravel, sand, silt, and clay.
Other	Alluvial Floodplain Deposits (Qfp)	Holocene	recent	Composed of fine sands, silts, and clay
Other	Alluvial Deposits, Undivided (Qha)	Holocene	recent	Composed of cobble, gravel, sand, silt, and clay

APPENDIX B-1 (Continued)

Table B1-2
Summary of Landforms, Geologic Formations and Soils
in the SSHCP Study Area, with Associated Attributes

Landform	Geologic Formation	Period/Epoch	Age ² (Ma)	Parent Material/Description
Other	Basin Deposits (Qhb)	Holocene	recent	Composed of unconsolidated clay, silt, and fine sands formed in sink areas

Notes:

¹ Information compiled from Tugel (1993), Smith and Verrill (1998) and Vollmar.

² Age estimates of boundaries in mega-annum (Ma).

1.2 The Vernal Pool Hydrologic Cycle

California vernal pools are a subcategory of seasonal wetlands that are characterized by a very specific annual hydrologic regime, which is often cited as the strongest determinant in shaping vernal pool flora and fauna (see Section 1.3). Vernal pool basins transition through four hydro-ecologic phases during the course of a single year: (i) a wetting phase, (ii) an aquatic or inundation phase, (iii) a waterlogged-terrestrial phase, and (iv) a drought phase (Zedler 1987; Keeley and Zedler 1998). This seasonal hydrologic cycle encompasses extremes of inundation and drought, a regime that has been primary in shaping the highly specialized flora and fauna (Stone 1990). To the benefit of native biodiversity, this extreme hydrologic regime has also proven excessively stressful for the majority of non-native plant species that have come to define California's contemporary valley annual grassland habitats.

Differences in ecological function of vernal pools, and in patterns of vernal pool biodiversity are determined in large part by variance in vernal pool hydrologic regimes (Ebert and Balko 1984; Zedler 1987; Holland and Jain 1990; Jones and Stokes 1990; Jokerst 1990; Platenkamp 1998; Keeley and Zedler 1998). The characteristic concentric rings of species that occur around many vernal pools results from timing of germination and maturation relative to the seasonal inundation and dry-down of the pool basin and soil profile (Bliss and Zedler 1998; Keeley and Zedler 1998). Variance in vernal pool hydrology exists within and between pools/complexes within single years (Stone 1990; Holland and Jain 1984; Holland and Dains 1990), and within and among single pools/complexes between years.

A discussion of vernal pool types, or of variance in function of vernal pools requires thinking about the hydrologic regimes in terms of a gradient of inundation and dry-down severity of the pool basin and soil profile. At one end of the topo-hydrologic gradient are "flashy, shallow, small" pools with shallow soils and at the other end are "stable, deep, large" pools with deep soils. At a slightly higher/drier topo-hydrologic position, the "flashy/small" vernal pool type intergrades with less specialized and mostly non-native seasonal wetland species, and then at a slightly higher and drier position, with upland annual grassland vegetation. At a slightly

APPENDIX B-1 (Continued)

lower/wetter topo-hydrologic position, the “stable/large” vernal pool type intergrades with seasonal marsh vegetation, comprised mostly of comparatively common and widespread perennial wetland plant species.

The full spectrum of the vernal pool hydrologic cycle can occur within individual large/deep vernal pools during a typical year. In these larger systems, hydrology similar to that of “flashy-smaller” pools can be associated with the topographic higher and drier edges, and “stable” pool hydrology with the deeper pool basins; the intervening slope is intermediate. In a given vernal pool complex, smaller/flashy pools tend to support a vegetation assemblage that represents a higher/drier subset of the larger/stable pool vegetation assemblage in the same setting.

Although “flashy-smaller” pool hydrology and vegetation can be considered as a subset of the larger pool system, “flashy-smaller” pools likely differ from large pools in a number of physical parameters and ecological functions. This may be reflected in the preference of some vernal pool invertebrates for the smaller pool type (Helm 1998; Helm and Vollmar 2002; Simovich 1998).

Different topo-hydrographic pool types function differently within a given hydrological season. For instance, small/shallow pools fill earlier and dry-down earlier over the hydrological season, at times even filling and drying more than once in a single year (Jones and Stokes 1990). Large pools take a longer time to fill and remain inundated longer into the later spring and early summer months. In addition, they almost never completely fill and dry more than once per hydrological year.

These different pool types undoubtedly behave differently through extended dry and wet climatic cycles as well. During very dry periods, large pools may never completely fill, but may still support vernal pool biota in the deepest portions that is characteristic of shallower pools or higher topo-hydrological positions during wetter years. During these dry periods the smallest flashy pools lack the specialized hydrology to support the more deeply adapted elements of the vernal pool biota altogether. During wetter climatic cycles, large pools may begin to function more like emergent marsh habitats, with increasing cover of perennial marsh species in the deeper portions (e.g., common spikerush), and small-flashy pools may begin to resemble the condition of larger vernal pools during drier cycles.

Juxtaposition of interconnected large and small pools together in a single landscape setting probably affords stability to the associated vernal pool biotic assemblage during long periods of time and under fluctuating climatic conditions (Jones and Stokes 1990).

Alteration of the hydrology of vernal pools/complexes may result in shifts towards a seasonal marsh ecosystem if the inundated and/or waterlogged-terrestrial phases of the cycle are prolonged, or towards a less specialized seasonal wetland ecosystem if those phases are

APPENDIX B-1 (Continued)

shortened. Thus, consideration of watershed integrity, hydrological buffers, and spatial scale in the creation of vernal pool preserves is fundamental to vernal pool conservation.

Despite the importance of the hydrologic regime as a determining factor in shaping the ecology of vernal pools, few detailed studies exist which address the hydrologic dynamics that exist between the vernal pool sub-watershed, the surrounding soil profile, and pool hydrology. The most detailed study to date, conducted in Sacramento County within the Sunrise-Douglas Specific Study Area, documents the relative importance of direct precipitation, overland flow, and subsurface flow to the seasonal hydrological regime of a small set of vernal pools (Hains and Stromberg 1998). This research indicated that during the single year of data collection in this set of pools, direct precipitation was responsible for most of the hydrological input into pool basins, followed by subsurface flow through the soil profile from adjacent uplands later in the season. Although overland flow was not significant during the season of the study, the model produced indicates that under conditions of higher than normal rainfall, overland flow contributions would increase.

Dynamic relationships were found to exist between the hydrology of the vernal pool basin and the surrounding soil profile (Hains and Stromberg 1998). In the study pools, water flowed from the ponded basin into the drier surrounding upland soils early in the season, and from the saturated upland soils into the pond basin later in the season, thus buffering the pool's inundation regime against excessively rapid filling early in the season, and against rapid drying later.

1.3 Influence of Vernal Pool Hydrology on Biotic Assemblages

The extreme seasonal inundation and drought conditions of the vernal pool hydrologic cycle exert strict demands on the plant and animal inhabitants. As a result, vernal pool organisms possess a suite of life history (Zedler 1990), morphological (Griggs 1974, 1980), and anatomical and physiological (Feaver 1971; Keeley 1981, 1988, 1990, 1998) adaptations that allow them to cope with challenges imposed by the habitat.

In general, all vernal pool organisms have evolved life history adaptations as a way to take advantage of the short, stressful growing season, and to avoid the regular extreme summer drought (Zedler 1990, Kelley and Zedler 1998). The vast majority of vernal pool endemic plant species exhibit an annual life cycle (Zedler 1990). The ability to germinate, grow, and complete reproduction within one growing season allows populations of plants to pass the summer drought as seeds on/in the soil. Similarly, vernal pool invertebrates hatch from their dormant cysts/eggs after the pools fill; they mate, produce cysts/eggs, and die as the pools dry. For populations of these species, the summer is spent on/in the soil in the form of dormant cysts/eggs (Keeley and Zedler 1998). Storage of drought-dormant seeds/cysts in the soil profile may also afford stability to populations over multiple-year drought cycles (Griggs and Jain 1983; Holland 1987; Stone et al. 1988).

APPENDIX B-1 (Continued)

The inundated phase presents its own challenges to growth and survival, and an amphibious life history, with corresponding aquatic juvenile morphology and physiology, is an adaptive trait shared by plants and animals alike (Keeley and Zedler 1998). Like vernal pool amphibians, many vernal pool plant species possess dual morphology, with a juvenile grass-like (Isoetid) leaf form that is adapted for maximal growth underwater during the vernal pool inundated phase (Keeley 1981 1990, and 1998).

As the pool progresses through the waterlogged-terrestrial phase and into the drought-phase, the plants assume a different adult morphology that is suited to growth in the terrestrial setting. Adult amphibian vertebrates, including western spadefoot toad (*Spea hammondi*) and California tiger salamander (*Ambystoma californiense*), congregate, mate and lay egg masses in vernal pools during the inundated phase; the eggs hatch to produce aquatic larvae (pollywogs), which mature and metamorphose into the adult terrestrial form before the pool basins completely dry. The metamorphosed juveniles of the season and older adults then migrate to rodent burrows in the uplands after the pools dry to pass the summer in a state of dormancy.

Parameters of vernal pool hydrology (e.g., ponding duration, ponding depth, soil depth and water-holding capacity) have been variously correlated with patterns of plant (Alexander and Schlising 1998; Holland and Dains 1990; Stone et al. 1988; Platenkamp 1998; Dittes and Guardino 2002), invertebrate (Helm 1998; Helm and Vollmar 2002; Platenkamp 1998; Simovich 1998), vertebrate amphibian (Laabs, Orloff and Allaback 2002; Morey 1998), and avian biodiversity (Silviera 1998).

In general, larger/deeper vernal pools have potential to support a wider array of topographic positions and greater overall plant diversity, as well as populations of “large pool” plant and animal species, including Orcuttiae grasses, legumens (*Legenere limosa*), California tiger salamander, western spadefoot toad, and vernal pool tadpole shrimp (*Lepidurus packardii*). All of these “large-pool” species require a relatively extended inundation phase for completion of their life cycles, as compared with more frequently occurring vernal pool taxa adapted to shorter inundation regimes.

While larger/deeper pools provide specialized habitat conditions that support several listed plant and animal species, smaller/flashy pools also provide important habitat for listed species. Two such invertebrate species are the vernal pool fairy shrimp (*Branchinecta lynchi*) and mid-valley fairy shrimp (*B. mesovallensis*), which have adapted to short inundation regimes by completing their life cycle in a relatively short amount of time. Similarly, Ahart’s dwarf-rush (*Juncus leiospermus* var. *ahartii*), and to some extent, dwarf downingia (*Downingia pusilla*) and pincushion navarretia (*Navarretia myersii*), are rare plant species that are adapted to the “flashy small” pool type.

1.4 Influence of Vernal Pool Interconnectivity on Biotic Assemblage

Interconnectivity is an important consideration for vernal pool conservation for a number of reasons. A landscape encompassing multiple pools of varying sizes located in close proximity to each other is ecologically complex, presents comparatively more niches, is more likely to support meta-population dynamics, and is likely to be more resilient through time, particularly in light of climatic fluctuations, as compared to a landscape with low density and/or low diversity of pool types.

It is useful to consider vernal pool ecosystem interconnectivity at three different spatial/functional scales.

Ecological interconnectivity between individual vernal pools within complexes and between vernal pool complexes mediated by contiguity of hydrology,

Ecological interconnectivity between pools and pool complexes at a local scale as mediated by contiguity of upland matrix,

Ecological interconnectivity between vernal pool complexes in the region as mediated by attractiveness of vernal pool landscapes to waterfowl and shorebirds migrating along the Pacific Flyway.

Interconnectivity at each of these scales involves a set of functioning physical biological components and presents specific ecological implications for associated vernal pool biota.

Hydrological interconnectivity between individual vernal pools or between vernal pool complexes can occur through the soil profile, as surface sheet flow over the soil profile, or by movement of water through swales or seasonal drainages. Alteration of pool or swale hydrology within hydrological-related pool complexes may affect the hydrology of other pools within those complexes. In addition to influence of hydrologic regime, interconnectivity via swales and drainages also presents dispersal opportunities for myriad vernal pool organisms, including rare vernal pool plants, invertebrate and amphibian species that are covered under the SSHCP.

Ecological interconnectivity between pools and pool complexes via contiguity of the upland matrix is an important consideration for life-history needs and dispersal of vernal pool organisms as well. Amphibians, including western spadefoot toad and California tiger salamander, require contiguous uplands for summer aestivation and for terrestrial migration of adults between core and satellite elements within larger meta-populations. Plant seeds and invertebrate cysts and eggs may also be transported between vernal pools across contiguous uplands in mud on the hooves or legs of livestock. Solitary bees that are obligate vernal pool plant pollinators depend on the

uplands surrounding vernal pools as well, and it is not known what interconnectivity means for them regarding the temporal and spatial scale of meta-populations.

In addition, attraction of a given pool or pool complex to migratory waterfowl and shorebirds is likely influenced by the juxtaposition of the pools/complexes with each other and with the immediately surrounding uplands. Similarly, at the regional scale, juxtaposition of vernal pools/complexes with each other, with other open-space areas, and with developed areas, undoubtedly influences attractiveness of those pools and complexes to migratory waterfowl and shorebirds traveling the Pacific Flyway. The use of pools/complexes by waterfowl and shorebirds affects dispersal of seeds and invertebrate cysts and eggs. This interconnectivity has biogeographic implications at both local and regional scales.

1.5 Vernal Pool Organisms

California vernal pools are defined in part by their highly adapted and unique assemblages of obligate-associated plants and animal species. Due to the significant loss of vernal pool habitat throughout California (see Section 4), the Federal Government and/or State of California has listed over 80 vernal pool organisms as Threatened, Endangered or candidates for Listing (Keeler-Wolf et al. 1998). Table 1 includes the 7 vernal pool endemic plant species and 6 vernal pool endemic animal species covered by the SSHCP. A brief discussion of their biology, ecology, and conservation considerations follows. For a more complete discussion of these organisms, refer to the individual SSHCP species accounts (Appendix A of the SSHCP). Legal status, distribution by County, and habitat associations for the 13 vernal pool species are listed in Table 1.

1.5.1 Vernal Pool Plants

Vernal pools support a uniquely adapted, mostly native, and highly endemic flora. The hydrologic cycle that defines this seasonal wetland type is excessively stressful for more commonly occurring wetland species, and it precludes most of the non-native plants species that dominate the surrounding present-day annual grassland. There are more than 100 native plant species that are more or less restricted to the vernal pool ecosystem (Keeler-Wolf et al. 1998; Keeley and Zedler 1998), 90% of these are native, and 55% are entirely restricted to California (Holland 1976; Keeler-Wolf et al. 1998). A typical vernal pool usually supports 15–25 species (Holland and Jain 1977, 1984; Zedler 1987).

The vernal pool flora is comprised of two biogeographic elements: strict California vernal pool endemics, and more widely occurring cosmopolitan aquatic species (Keeley and Zedler 1990). Most of the California vernal pool endemics are derived from upland progenitors that evolved into the developing vernal pool landscape since the Pleistocene (Stone 1990).

APPENDIX B-1 (Continued)

Vernal pool plant species composition has been shown to vary at multiple spatial scales, with 28% of overall variability occurring between state regions, 17% of variability occurring between areas at the scale of counties, and 55% of the variability occurring among pools within landscape complexes or “within pastures” (Holland and Jain 1981). Variability at the largest scale is influenced by climate, source biota, geological surface and site history (Holland and Dains 1990).

At the smallest scale, within pool variability in plant species composition is attributable mostly to variance in inundation regime (Kopecko and Lathrop 1975; Schlising and Sanders 1982; Zedler 1987; Holland and Jain 1988; Jokerst 1990; Keeley and Zedler 1998; Bauder 2000). Barbour et al. (2003) investigated within-pool variance in plant species composition and concluded that whole pool vegetation assemblages are complexes of several apparently independent communities, each of which can be found in other pools, and which may have individual geographic restrictions. The fact that greatest differences in community types were found between the deep and shallow parts of single pools is evidence of the strong selective force of the vernal pool inundation regime.

The terms “shallow pool species and deep pool species” or “edge species and basin species” have been used to describe contrasting preferences of plants for the different portions of the larger range of vernal pool hydrological regimes. A good example of a shallow pool or edge species is found in Ahart’s Dwarf Rush, one of the rare species covered under the SSHCP. Good examples of deep pool, or basin species are found in Sacramento and slender Orcutt grasses, two rare species also covered by the SSHCP. However, not all species are as easily assignable to the two categories. Vernal pool plants are able to occupy these hydrological-stressful habitats owing to genetically fixed physiological, structural (anatomical and morphological), and life history traits.

The majority of vernal pool plant species have evolved the annual life cycle (Stone 1990; Zedler 1990; Keeley and Zedler 1998). In this fashion plant populations avoid the predictable and extreme summer drought in the form of dormant seeds. Since not all seeds may germinate every year, some vernal pool plant species have been shown to maintain a persistent dormant soil seed bank that acts as a buffer against single or multiple years with poor rainfall (Griggs and Jain 1983).

Germination occurs either early in the season during the wetting phase, or later on during the inundation phase of the vernal pool annual hydrological cycle (Keeley and Zedler 1998). Many vernal pool species possess dual morphology, with a juvenile form specialized for growth in the aquatic phase, and then later an adult form that is more suited to conditions of the inundated terrestrial and drought phases of the hydrological cycle (Zedler 1990). It is common to see flowering and fruiting species at drying pool margins while at the same time other species are present as seedlings and aquatic juveniles in the inundated pool basin.

APPENDIX B-1 (Continued)

Seed dispersal of vernal pool plants tends to be limited. This is thought to be an adaptation to the discontinuous and unpredictable occurrence of vernal pools in the larger upland landscape. Successful germination, growth, and reproduction of a vernal pool plant seed is likely to be the highest in the same pool that supported the seed's parent plant. Most vernal pool plants lack specialized seed dispersal mechanisms. As a result, seeds tend to fall near the parent plant. Some dispersal of seeds also occurs via flowing water, on the hooves and legs of livestock (tule elk [*Cervus canadensis nannodes*], antelope [*Antilocapra americana*] and grizzly bears [*Ursus arctos horribilis*] originally), and on the feathers and feet of waterfowl and shorebirds, suggesting that some seeds may travel greater distances.

Genetics have been investigated for only a limited number of vernal pool plant species (Elam 1998). Owing to certain population traits (e.g., small or fluctuating population numbers) it is hypothesized that some vernal pool species are subject to effects of genetic drift. This is expected to result in reduced genetic diversity and a high degree of among-population (between pool) variation (Elam 1998). Other genetic characteristics of vernal pool plants include limited gene flow between pools (e.g., seed and pollen dispersal), high among-population (between pool) variation, and variable ecological selection within and between pools (Elam 1998).

Some vernal pool species are pollinated by wind (Orcuttiae grasses), some are self-pollinated (legumere, dwarf downingia) and others (e.g., *Lasthenia*, *Downingia*, *Blennosperma*, *Limnanthes*) by a suite of co-evolved specialist solitary bees of the family Andrenidae (Thorp and Long 1998, Thorp 1990). These solitary bees nest in small tunnels excavated in the uplands around vernal pools and rely on vernal pool plants entirely to supply pollen for their young while the plants, in turn, depend on the pollination services of the bees to produce seeds for the next generation..

See Appendix A of the SSHCP for specific life histories of vernal pool associated plants addressed in the SSHCP.

1.5.2 Vernal Pool Invertebrates

Invertebrates are a major part of California landscapes with respect to species richness, abundance and total biomass. Insects are especially diverse and dominant in terrestrial environments, but they can also share dominance of freshwater environments with crustaceans (Hickman et al. 2001). Insects are nearly absent in marine environments, perhaps because of the early occupancy of these aquatic habitats by a great number of crustaceans (Evans 1984). The only successful move of crustaceans to terrestrial habitats has been by the isopods (popularly known as pill bugs) (Hickman et al. 2001).

One well-known group of crustaceans, the branchiopods, has some members that are found only in vernal pools. Vernal pool branchiopods include fairy shrimp (Anostraca), tadpole shrimp

APPENDIX B-1 (Continued)

(Notostraca) and clam shrimp (Conchostraca). California hosts at least nine endemic and up to 29 total fairy shrimp species (Bauder et al. 1997), four of which are listed as endangered and one as threatened under the Federal Endangered Species Act (FESA). Fairy shrimp do not occur in running waters and none are true marine organisms (Zedler 1987). Branchiopods occurring within the SSHCP Study Area are the mid-valley fairy shrimp (*Branchinecta mesovallensis*), vernal pool fairy shrimp (*Branchinecta lynchi*) and the vernal pool tadpole shrimp (*Lepidurus packardii*).

The only vernal pool insect covered under the SSHCP is the Ricksecker's water scavenger beetle (*Hydrochara rickseckeri*). See Appendix A of the SSHCP for specific life history of Ricksecker's water scavenger beetle.

Vernal Pool Crustaceans

In a survey of California vernal pools Simovich (1998) found 67 species of crustaceans and 60-100 species of insects and other invertebrates. Aquatic crustaceans found in vernal pools include branchiopods (fairy shrimp, tadpole shrimp, and clam shrimp), cladocerans (water fleas), copepods, ostracods (seed shrimp), and rotifers (Zedler 1987). Crustacean diversity in vernal pools is mediated by a number of possible factors such as inundation period and pool size (Simovich 1998). Inundation period regulates presence of crustaceans based on time required for development. Long inundation periods may allow the co-existence of similar (especially congeneric) species by reducing temporal overlap. Vernal pools of varying sizes may provide more available niches for crustaceans to inhabit, increasing diversity.

Crustaceans are sometimes more diverse in ephemeral than in permanent water bodies, perhaps due to decreased predation and non-limited resources (Simovich 1998). Historical climatic fluctuations may have created opportunities for gene exchange between previously isolated gene pools as vernal pool complexes expanded and retracted in response to increased dry and wet periods. Genetic variability in vernal pool crustaceans found within populations (i.e. within pools) may be a result of fluctuating selection and generation overlap (Simovich 1998) that occurs as a result of prolonged diapause (Ellner et al. 1999). The combination of typically large crustacean cyst banks in vernal pools (Belk 1998) together with overlapping generations (due to lack of all cysts hatching each year) creates the potential for significant within pool genetic variation (Simovich 1998).

Dispersal capability sets a limit on the distribution of any organism. As crustaceans cannot fly, their dispersal is limited to passive movement. Simovich (1998) and Ahl (1991) postulated that crustacean dispersal between vernal pool complexes probably occurs by movements of birds that eat crustacean disseminules. Proctor (1964) and Proctor and Malone (1965) found that disseminules were passed successfully through the intestinal tracts of mallard ducks, chickens, pigeons and canaries. Proctor et al. (1967) found that viable disseminules were retained for

APPENDIX B-1 (Continued)

longer periods in killdeer than in mallard ducks, suggesting that killdeer and similar shorebirds could possibly be more effective than ducks as dispersal agents for aquatic organisms, as they can carry disseminules longer distances. Large-scale flood events, which no longer occur due to levees and damming of major rivers, are postulated as influential in dispersal of crustacean disseminules historically (USFWS 1999). Dispersal is critical for the long-term survival of these species (LAS 2004).

See Appendix A of the SSHCP for specific life histories of vernal pool associated crustaceans addressed in the SSHCP.

1.5.3 Aquatic Mollusks

Studies of two aquatic snails (*Fossaria sonomensis* and *Bakerilymnaea cockerelli*) in vernal pools by Gallagher (1993) and Newman (1973) found that both snails use a form of aestivation (summer dormancy) to avoid the extreme drought of the summer-dry vernal pool. These snails migrate into the sediments before the pool dries, reappearing as the first inhabitants of vernal pools when flooding occurs. Snails lay egg masses inside vernal pools, making snails totally dependent on pools as are fairy shrimp and tadpole shrimp. Gallagher (1993) also found that vernal pool inundation period was an important factor in regulating snail dynamics. Alexander (1976) postulated that stonefly larvae are potentially significant predators on snail egg masses in vernal pools.

1.5.4 Vernal Pool Insects

Most insects that use California vernal pools are winged opportunists, utilizing vernal pools when available but abandoning them as soon as they become unsuitable (Zedler 1987). Common large aquatic insects known to visit vernal pools include predaceous dragonfly nymphs, backswimmers, water boatmen, predaceous diving beetles and water scavenger beetles. Flies are reported from vernal pools as well, but are probably largely accidental (Zedler 1987).

Surveys of natural and constructed pools in Folsom County, California, found 58 species of insects inhabiting vernal pools including one springtail (Collembola), one mayfly (Ephemeroptera), four dragonflies (Odonata), nine true bugs (Hemiptera), one stonefly (Trichoptera), 26 beetles (Coleoptera) and 16 flies (Diptera) (Rogers 1998).

Although the role of insects in vernal pool ecology is probably substantial, little is known about the insects that inhabit vernal pools (Zedler 1987). Terrestrial insects may serve as food sources for vernal pool organisms, prey on or compete with vernal pool organisms, and have some indirect effects on vernal pool ecology.

Mosquitoes are of concern to the public owing to their potential to spread disease, including West Nile Virus and Encephalitis. Detailed studies of mosquitoes in vernal pools are mostly

APPENDIX B-1 (Continued)

lacking. In a survey of aquatic macro-invertebrates in 27 natural and 37 artificially constructed pools, Rogers (1998) found that mosquito larvae and midge larvae together comprised less than 2% of the invertebrate richness in natural pools. Some of the artificial pools were similar to natural pools with regard to mosquito and midge populations. During the 2nd year of this study however, these fly species comprised between 40% and 78% of the invertebrate composition in pools at one site. In general, it is thought that functioning vernal pools do not provide optimal breeding habitat for mosquito populations because they support a diversity of predatory invertebrate species (water beetles, backswimmers, tadpole shrimp, amphibian larvae) that feed on the aquatic mosquito larvae (Rogers pers. comm.; Alexander pers. comm.).

Flower Visiting Insects

The most conspicuous terrestrial insects associated with vernal pools are oligolectic bees. Oligolectic bees only visit a small number of closely related plants (e.g. *Limnanthes*, *Lasthenia*, *Blennosperma*) for pollen food. These specialized bees are important to vernal pool plants and overall vernal pool ecology (Bauder et al. 1997; LSA 2004; Thorp 1976, 1990; Thorp & Leong 1995, 1996, 1998). The highest percentages of specialist-feeding bees occur in areas of California with a Mediterranean and desert climate. These bees rely entirely on their local, specific food plants and on the availability of suitable nest habitat.

Vernal pool specialist bees are critical pollinators of vernal pool plants because of their inherent fidelity to these plants. This relationship highlights the importance of maintaining the connections between vernal pools and the uplands surrounding them. The bees construct nests primarily in upland areas near pools (although nests have been found in created pools; (S. Chamberlain, pers. obs.) and probably do not move far from their nest sites. Leong and Thorp (1995) found that most bees they studied did not travel more than about 0.5 mile. Fragmentation of vernal pool habitats increases distances between pools, possibly inhibiting movement of these dispersal-limited bees (Leong and Thorp 1995), and decreasing visitation rates to their associated flowers. Decreased visitation rates may result in lower seed output, reducing the size of the soil seed bank, the “insurance policy” of vernal pool plants against unfavorable hydrological conditions.

1.5.6 Amphibians

There are four amphibians known to inhabit vernal pools within the SSHCP Study Area, including the Pacific chorus frog (*Pseudacris regilla*), western toad (*Bufo boreas*), western spadefoot toad and the California tiger salamander. The western spadefoot toad and the California tiger salamander are covered under the SSHCP.

See Appendix A of the SSHCP for specific life histories of vernal pool associated amphibians addressed in the SSHCP.

APPENDIX B-1 (Continued)

1.5.7 Birds

Vernal pools and vernal pool complexes are important to the conservation of many bird species. Silveira (1998) reported observing 86 different taxa (44 waterbirds and 42 landbirds) using vernal pools and associated uplands at eight areas in the Sacramento Valley and from two areas in northeastern California. These birds use a variety of vernal pool types, visit pools differently at different times of year and exploit different microhabitats within a given pool (Silveira 1998).

Birds are important to the conservation of vernal pool species, as they are essential for the dispersal of vernal pool disseminules from one pool to another. Migratory birds moving along the Pacific Flyway spread plant seeds as well as invertebrate eggs and cysts between vernal pool complexes. Dispersal is important to populations as it limits isolation that can lead to inbreeding and reduces the chances of local extirpation.

1.5.8 Waterfowl and Shore Birds

During the wet season, waterfowl and shorebirds visiting vernal pools feed on a wide variety of food sources, rest, and in some cases nest. Some birds feed on invertebrates from the deeper portion of the pools, while others forage along the shoreline feeding on invertebrates or grazing the vegetation (Silveira 1998; Sloat and Whisler 2002). Vernal pools provide essential high protein food sources to migratory birds at a time critical to the development of building flight muscles and reproductive organs (Silveira 1998; USDO I 1994).

Waterfowl tend to use vernal pools with larger surface areas more often than smaller pools (Baker et al. 1992), however smaller pools are also frequently used, especially for individual breeding pairs (Silveira 1998). Uplands associated with vernal pools are also heavily used by Canada geese (*Branta canadensis*), which require new vegetation growth late in the winter and early in the spring for protein (Silveira 1998; Bogiatto pers. comm.).

A study of shorebird use of Central Valley habitats did not include large areas of vernal pool grasslands, and therefore did not report much use of vernal pool habitat by shorebirds (Shuford et al. 1998). In contrast, a study conducted over two spring seasons at the Sacramento National Wildlife Refuge, showed that although vernal pools comprised less than 2% of the refuge's total available wetland habitat, they held the highest shorebird densities, and more species preferred vernal pools than any other wetland type (Feldhiem et al. 1999).

Although waterfowl and shorebirds require these seasonal wetlands to help complete their migration and are important to the conservation of vernal pool species, these birds are not specifically covered under the SSHCP.

2 VERNAL POOL FUNCTIONS AND ECOSYSTEM SERVICES

2.1 Functions

Vernal pool functions have been defined as the hydrologic, biogeochemical, and habitat support processes that characterize and define vernal pools as self-maintaining wetland ecosystems (Butterwick 1998). The term “Values” as applied to vernal pool ecosystems is a more subjective concept. Ecosystem values relate to the perceptions of people and society regarding vernal pools; these perceptions reflect cultural, socioeconomic and policy issues that can change over time (Butterwick 1998; NRC 1995).

Consideration of ecosystem function is the basis of the Hydrogeomorphic (HGM) approach to wetland assessment (Environmental Protection Agency [EPA], United States Army Corps of Engineers [ACOE]), which likely represents one of the more comprehensive frameworks and cohesive descriptions of vernal pool functions and ecosystem processes. Ten vernal pool functions have been proposed as part of the draft HGM approach; each function is associated with one of three categories: hydrology, biogeochemistry, and habitat support (Butterwick 1998). Each vernal pool ecosystem function is described below, along with a brief discussion of determinant factors, functional variance, and relationships among functions.

The HGM approach represents a conceptual framework that is useful in facilitating communication about an exceedingly complicated ecological phenomenon. It is important to recognize that in nature these 10 vernal pool ecosystem functions are closely interrelated and overlap in the processing through time of elements, compounds and genetic information. Additionally, these functions operate and interrelate in causal-dependent relationships at multiple spatial and temporal scales: from within single vernal pools within a single annual hydrologic cycle, to among all vernal pool complexes on a given set of geologic landforms over evolutionary time.

Finally, it is important to acknowledge that paradoxically, landscape-level ecosystem function and related evolutionary dynamics are critical components of long-term conservation planning/management, yet they are not readily perceivable and they are difficult to define and to quantify.

2.1.1 Hydrology (3 Functions)

Function 1- surface water storage is the capacity of the vernal pool basin to pond water seasonally and retain surface water for long duration. This function is dependent on a variety of factors, including but not limited to surface topography (e.g., area of drainage, dimensions of depression basin), soil depth and water-holding capacity, and the nature of the water-impermeable layer in the soil profile.

APPENDIX B-1 (Continued)

Function 2- subsurface water exchange is the capacity of the subsurface area above the restrictive layer to hold water and allow exchange of water between the pool basin and the surrounding landscape. This function is dependent on a variety of factors, including but not limited to the water holding capacity of the soil, soil permeability, and soil depth. These factors together influence the dynamics of water exchange between pool basins and surrounding pool and upland areas.

Function 3- surface water conveyance is the capacity to convey concentrated inter-storm water flow into and out of pool basins through swales. Swales lack bed and bank morphology yet they are critical components of drainage and interconnectivity of vernal pool-annual grassland landscapes. This function is dependent on a number of factors, including but not limited to topography, the nature of the soil profile, and the juxtaposition of pools/pool complexes within sub-watershed areas.

2.1.2 Biogeochemical (2 Functions)

Function 4- element removal is the capacity of vernal pools to remove and concentrate imported nutrients, contaminants, elements and compounds from the water through abiotic and biotic processes. This function is dependent on myriad physical, chemical and biological components of the ecosystem.

Function 5- element cycling is the capacity of vernal pools to support biogeochemical processes that convert and recycle elements and compounds from one form to another. The vernal pool biota provides both material and metabolic process to the function of element cycling. The annual development and decay of plant and animal biomass involves cycling (assimilation, conversion, release and breakdown) of myriad inorganic elements and organic and inorganic compounds.

2.1.3 Habitat Support (5 Functions)

Function 6- maintenance of characteristic vegetation is the capacity of vernal pools to support a characteristic suite of native plant species. Vernal pool plant species are uniquely adapted to the extreme regimes of inundation and drought that defines the annual vernal pool hydrologic cycle.

Function 7- maintains characteristic aquatic invertebrates is the capacity of vernal pools to provide the hydrologic, chemical, and temperature conditions that are required to support their characteristic aquatic invertebrate fauna. Like vernal pool plant species, vernal pool invertebrate species are uniquely adapted to the extreme regimes of inundation and drought that defines the annual vernal pool hydrologic cycle.

Function 8- maintains amphibian and avian populations is the capacity of vernal pools to provide suitable aquatic and terrestrial habitat for amphibians to complete their entire life cycle,

APPENDIX B-1 (Continued)

and for resting, feeding, hiding and reproduction of avian populations. Amphibian and avian species both depend on the quality of contiguous uplands, and particularly for birds, the juxtaposition of wetlands with other wetlands and habitat types (see Function 10).

Function 9- maintain populations of sensitive taxa is the capacity of vernal pools to perpetually support populations of rare, threatened or endangered species, almost all of which are strict vernal pool endemics. It should be noted that this function might not be discernible from Functions 6, 7 and 8 above, since sensitive taxa represent a subset of the vernal pool biotic assemblage; they are dependent on and interact with the same physical and biological conditions, functions and process as their more common vernal pool associates. The presence or absence of any given species, rare or otherwise, may depend as much on biogeography and history as on particular characteristics of a given vernal pool. A vernal pool does not need to support sensitive species to qualify as a fully functioning vernal pool, whereas nearly all of the other 10 functions mentioned here are essential. For these reasons, and because designation of species as sensitive is somewhat subjective in itself, Vernal Pool Function 9 may more appropriately be considered as a “Vernal Pool Value” (see Section 3.2.2).

Function 10- maintain habitat interspersions and connectivity is the capacity of vernal pools to interact with other vernal pools, vernal pool complexes and other wetland and upland habitat types. The juxtaposition of vernal pools and vernal pool complexes across the landscape influences meta-population dynamics, migration, recruitment, establishment and persistence of species through time and space, and the long-term dynamics of population genetics (evolution).

2.2 Ecosystem Processes (Values)

Vernal pool (wetland) values are those qualities and/or functions of the ecosystem that relate to societal perceptions of “goods and services” (Butterwick 1998; NRC 1995). These values are subjective because they relate not only to complex interrelated parameters of the vernal pool ecosystem, but also to the prevailing socio-economic, political and educational status of California’s human population. Wetland ecosystem values, considered as a function of societal perception, vary not only through time in a given geographic area, but also across geography at any point in time (NRC 1995).

Since vernal pool habitats are generally part of larger watershed-scale systems, they may play various roles in the hydrological function of the larger landscape. By retaining direct precipitation as well as seasonal overland and subsurface flow during the rainy season, they buffer against flooding in downslope areas, and large complexes may even affect microclimate when hydrated during the warmer spring and early summer months by modifying local temperatures (the opposite of roofing or asphalt, which tend to increase local temperatures). Since vernal pools also function in geo-chemical processes (element removal and cycling), they

APPENDIX B-1 (Continued)

potentially mediate water quality when interconnected via swales or drainages, by assimilating and processing dissolved and suspended pollutants in runoff, and atmospheric pollutants precipitated in rainfall or dust.

3 HABITAT DISTRIBUTION

3.1 California Distribution

In California, vernal pool habitats occur in settings ranging in elevation from about 10 feet in Solano County to over 5,500 feet in Plumas County (CDFG 2003), and in association with a variety of geologic formations. The greatest areas of vernal pool habitat though, are associated with the Great Central Valley (Holland and Jain 1977; Holland 1978; Stone 1990). Areas of vernal pool habitat are also associated with the coastal terraces of San Diego County (Zedler 1987), and with scattered sites in the low elevation regions of the Peninsular and south and north Coast Ranges, the Sierra Nevada Range Foothills, the Cascade Range Foothills, and the Modoc Plateau (Holland and Jain 1977; Zedler 1987; Holland 1986).

The first maps of vernal pool complexes within the Central Valley were produced for CDFG by Holland (1978) and are shown in Figure 1. The most recent treatment of California vernal pools recognizes 17 biogeographically defined Vernal Pool Regions (Figure 2), including the San Diego, Western Riverside County, Santa Barbara, Carrizo, Central Coast, Livermore, San Joaquin Valley, Southern Sierra Foothills, Southeastern Sacramento Valley, Northwestern Sacramento Valley, Northeastern Sacramento Valley, Solano-Colusa, Santa Rosa, Lake-Napa, Mendocino, Sierra Valley, and Modoc Plateau Vernal Pool Regions (CDFG 1998).

3.2 Central Valley Distribution

The largest total number of vernal pools and the largest most intact vernal pool complexes remaining in the state are found in the Great Central Valley (Holland and Jain 1988; Keeler-Wolf et al. 1998; Vollmar 2002). These are distributed among 6 of the 17 biogeographic areas, including the San Joaquin Valley, Southern Sierra Foothills, Solano-Colusa, Northwestern Sacramento Valley, Northeastern Sacramento Valley, and Southeastern Sacramento Valley Vernal Pool Regions. The SSHCP Study Area is included entirely within the Southeastern Sacramento Valley Vernal Pool Region (Keeler-Wolf et al. 1998).

The Southeastern Sacramento Valley Vernal Pool Region includes all of the vernal pool complexes located within Sacramento, Placer, Amador, and El Dorado Counties, as well as a portion of the pool complexes located in northwest Calaveras County, northeast San Joaquin County, southern Yuba County, and as indicated in Figure 3, a small inclusion of pools in southern Sutter County. It has been noted that, although there are bio-geographical differences, the boundary between the Southeastern Sacramento Valley Vernal Pool Region and the Southern Sierra Foothills Vernal Pool Region is defined in part by jurisdictional areas of regulatory agencies and the treatments of bioregional assessment teams (Keeler-Wolf et al. 1998).

3.3 SSHCP Study Area Distribution

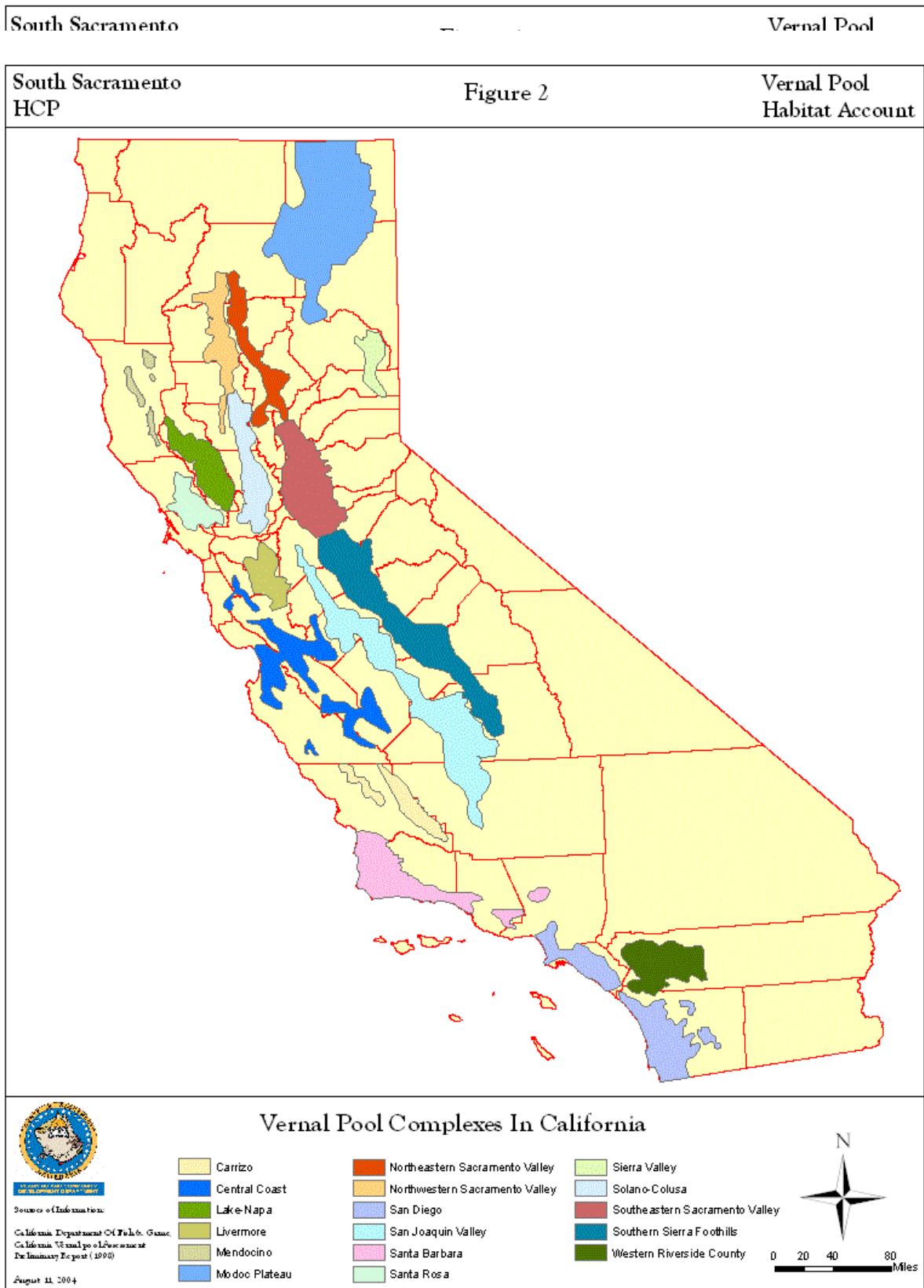
The SSHCP Study Area encompasses a significant portion of the vernal pool complexes that remain within the Southeastern Sacramento Valley Vernal Pool Region, as indicated in Figures 1 through 3. The current extent and distribution of vernal pools/wetlands in the SSHCP Study Area is illustrated in Figure 4. This map (Figure 4) was produced by the Geographic Information Center (GIC) at California State University, Chico using digital ortho-rectified black and white aerial photographs that were flown on March 15, 2001. For a more detailed description of this mapping procedure and constraints and assumptions relating to the map data, refer to Section 5.2 of this document.

The remaining extant vernal pool/annual grassland complexes located within the region as of 2001 are mostly concentrated in the south-eastern portion of Sacramento County. Here they are associated with 18 geologic formations that occur within the boundaries of the SSHCP Study Area, as illustrated in Figure 5.

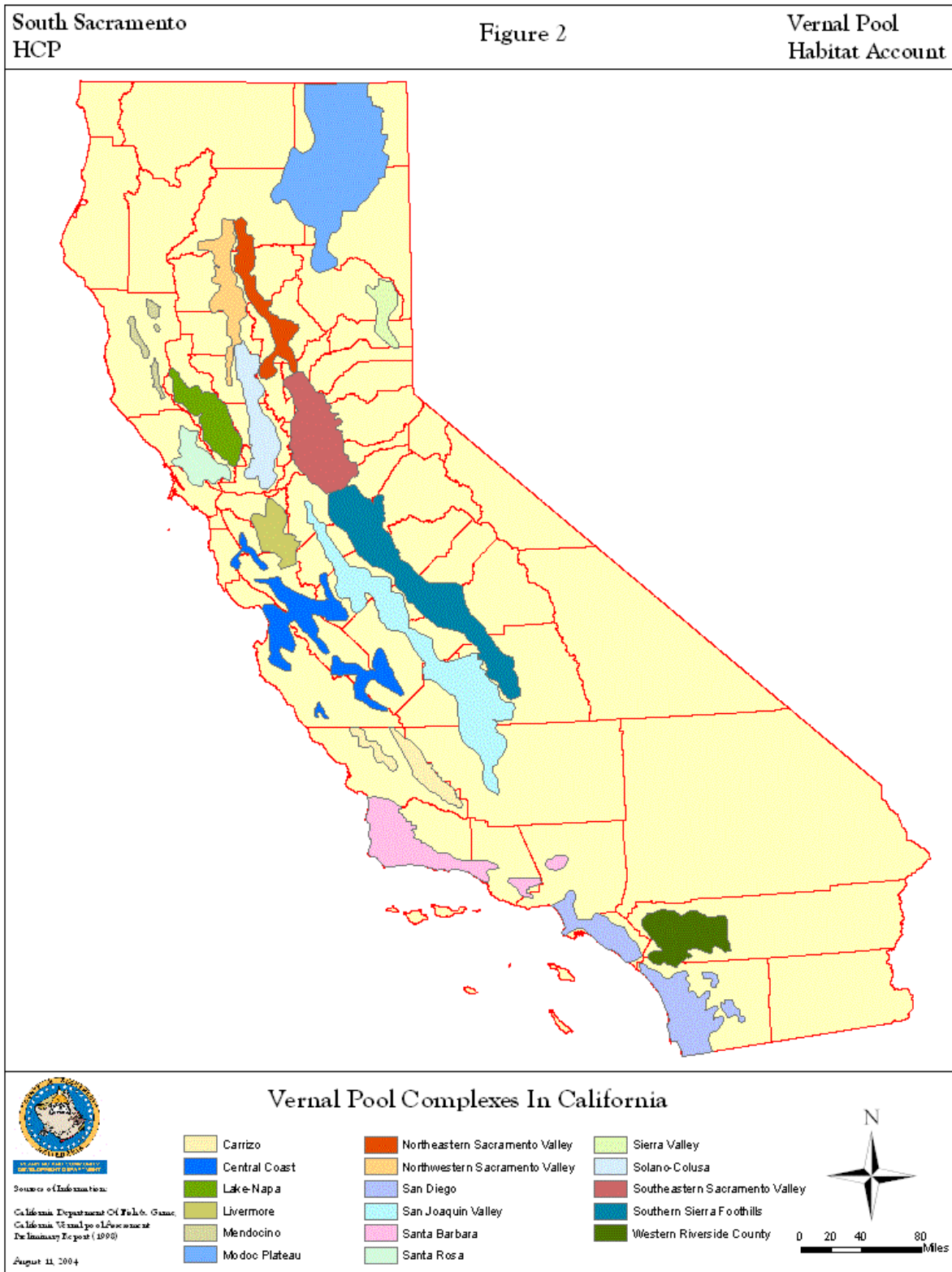
Table B1-3 numerically summarizes the distribution of vernal wetlands across geologic formations in the SSHCP study area. This table contains the total number of acres represented by each geologic formation and the total number of vernal wetted acres occurring on each formation within the SSHCP Study Area. Totals calculated for each geologic formation are also presented as percentages of the total vernal wetted area and total land area.

The number of vernal wetlands and total wetted acres for each geologic formation that contain vernal features within the SSHCP Study Area are presented in Table B1-4. These parameters are further described for the vernal wetlands both inside and outside the Urban Development Area (UDA); Figures 6 and 7 illustrate these data.

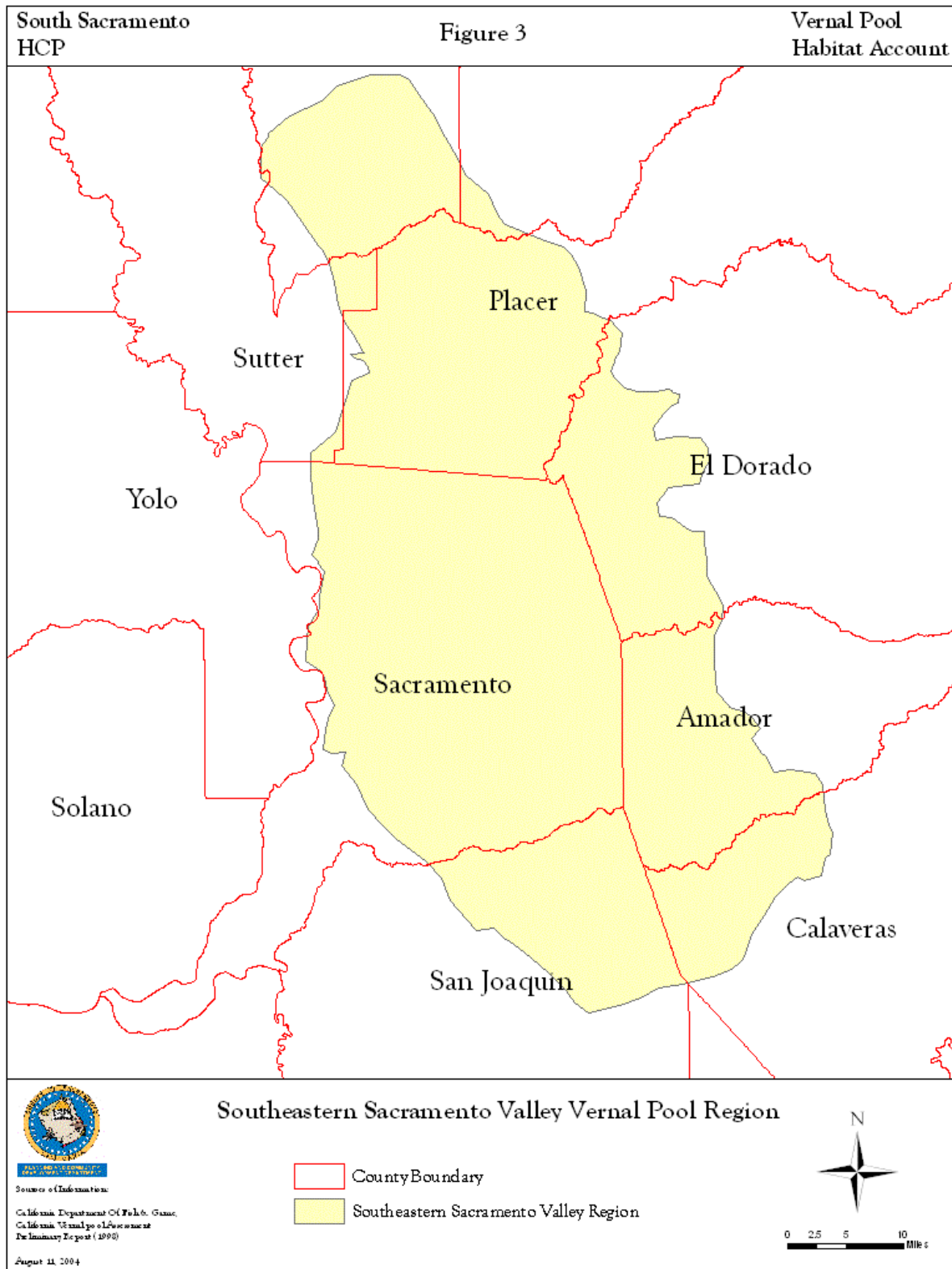
APPENDIX B-1 (Continued)



APPENDIX B-1 (Continued)



APPENDIX B-1 (Continued)



APPENDIX B-1 (Continued)

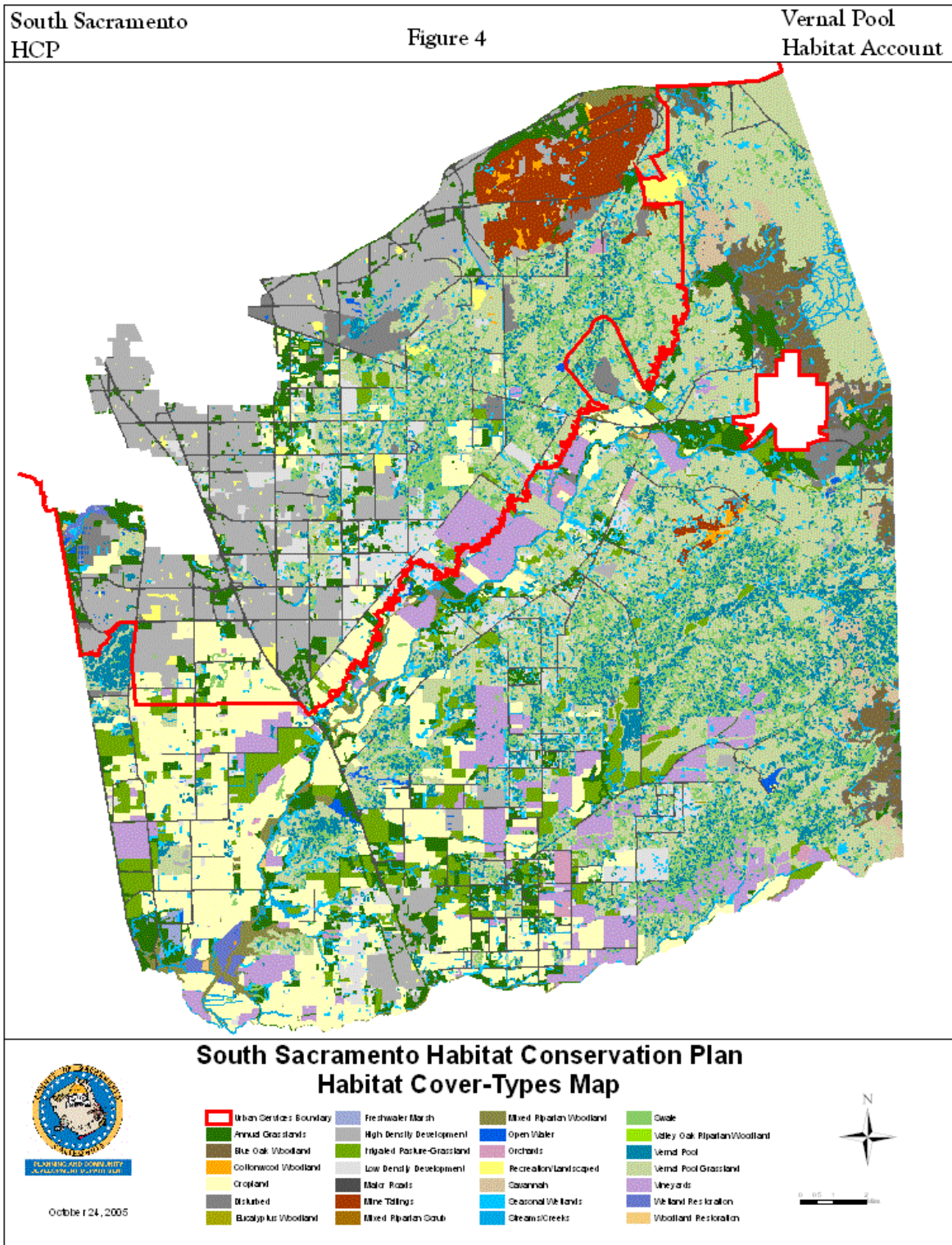
Table B1-3
Land and Vernal Wetland Acre Distribution
by Geologic Formation in the SSHCP Study Area

Geologic Formation	Land Area (acres)	Vernal Wetland Area (acres)	Percent of Formation Occupied by Vernal Wetland Area (%)	Percent of Total Vernal Wetland Area (%) ¹	Percent of Total Land Area (%) ¹
Laguna (Tl)	67,582	1372.9	2.03	34.3	19.6
Riverbank, Lower Unit (Qrl)	53,357	494.8	0.93	12.4	15.5
Riverbank, Undivided (Qr)	51,425	700.6	1.36	17.5	14.9
Riverbank, Upper Unit (Qru)	28,212	303.9	1.08	7.6	8.2
Mehrten (Tm)	26,667	386.8	1.45	9.7	7.7
Metamorphic Rocks (pKu)	24,288	38.2	0.16	1.0	7.0
Riverbank, Middle Unit (Qrm)	18,953	187.5	0.99	4.7	5.5
Upper Unit Modesto (Qmu)	18,051	116.8	0.65	2.9	5.2
Dredge Tailing and Artificial Fill (t)	14,527	5.2	0.04	0.1	4.2
Valley Springs (Tvs)	13,648	248.1	1.82	6.2	4.0
Alluvial Floodplain Deposits (Qfp)	9,733	10.9	0.11	0.3	2.8
Undifferentiated Surficial Alluvial Deposits (Qu)	4,497	64.1	1.43	1.6	1.3
South Fork Gravels (Qsf)	3,975	48.8	1.23	1.2	1.2
Alluvial Deposits, Undivided (Qha)	3,419	1.6	0.05	0.04	1.0
Ione (Ti)	2,956	3.1	0.10	0.08	0.9
Turlock Lake (Tpl)	2,095	9.5	0.45	0.2	0.6
Basin Deposits (Qhb)	663	3.1	0.47	0.08	0.2
North Merced Gravels (Qtnm)	561	3.6	0.64	0.09	0.2
Total	344,609	3999.5	N/A	100	100

Notes:

¹ Total refers to the entire SSHCP Study Area, rather than individual geologic formations.

APPENDIX B-1 (Continued)



APPENDIX B-1 (Continued)

Table B1-4
Number of Vernal Wetlands and Wetland acres for each Geologic Formation within the SSHCP Study Area that Contain Vernal Features

Geologic Formation	Total Acreage Inside SSHCPA	Number of Vernal Wetlands			Wetland Acres		
		Total	Inside UDA	Outside UDA	Total	Inside UDA	Outside UDA
Laguna (TI)	67,582	26844	8484	18360	1372.9	587.5	785.4
Lower Unit Riverbank (Qrl)	53,357	1719	1055	664	494.8	107.1	387.7
Riverbank Undivided (Qr)	51,425	9095	1466	7629	700.6	107.2	593.4
Upper Unit Riverbank (Qru)	28,212	2546	240	2306	303.9	11.3	292.7
Mehrten (Tm)	26,667	9759	298	9461	386.8	14.8	372.1
Metamorphic Rocks (pKu)	24,288	829	17	812	38.2	0.3	37.9
Middle Unit Riverbank (Qrm)	18,953	1970	251	1719	187.5	22.6	165.0
Upper Unit Modesto (Qmu)	18,051	1888	1	1887	116.8	0.8	116.0
Dredge Tailing and Artificial Fill (t)	14,527	162	64	98	5.2	2.5	2.7
Valley Springs (Tvs)	13,648	4018	2	4016	248.1	0.1	248.0
Alluvial Floodplain Deposits (Qfp)	9,733	59	0	59	10.9	0	10.9
Undifferentiated Surficial Alluvial Deposits (Qu)	4,497	1550	568	982	64.1	23.8	40.4
South Fork Gravels (Qsf)	3,975	586	586	0	48.8	48.8	0
Alluvial Deposits, Undivided (Qha)	3,419	32	0	32	1.6	0	1.6
Ione (Ti)	2,956	89	0	89	3.1	0	3.1
Turlock Lake (Tpl)	2,095	342	342	0	9.5	9.5	0
Basin Deposits (Qhb)	663	4	0	4	3.1	0	3.1
North Merced Gravels (Qtnm)	561	84	41	43	3.6	2.2	1.4
Total	344,609	61576	13415	48161	3999.5	938.5	3061.4

Abbreviations are: UDA = Urban Development Area.

APPENDIX B-1 (Continued)

Figure 6 Number of Vernal Wetlands by Geologic Formation in the SSHCP Study Area. See Table B1-2 for Geologic Formation Names.

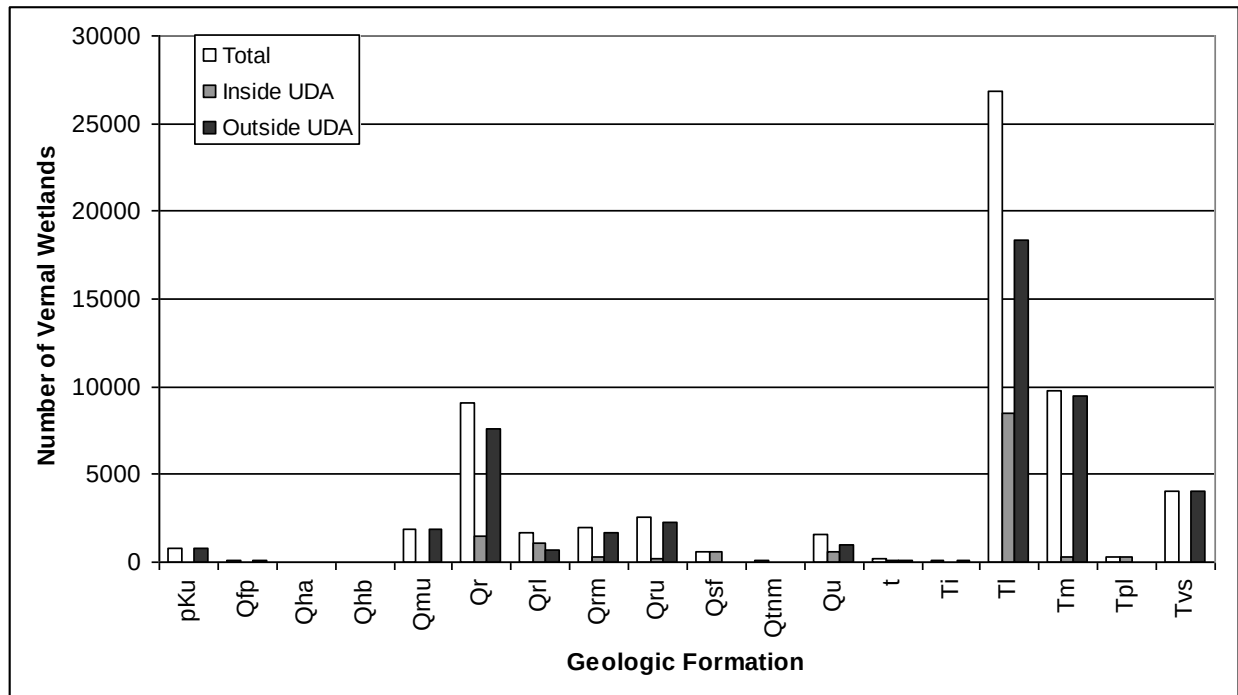
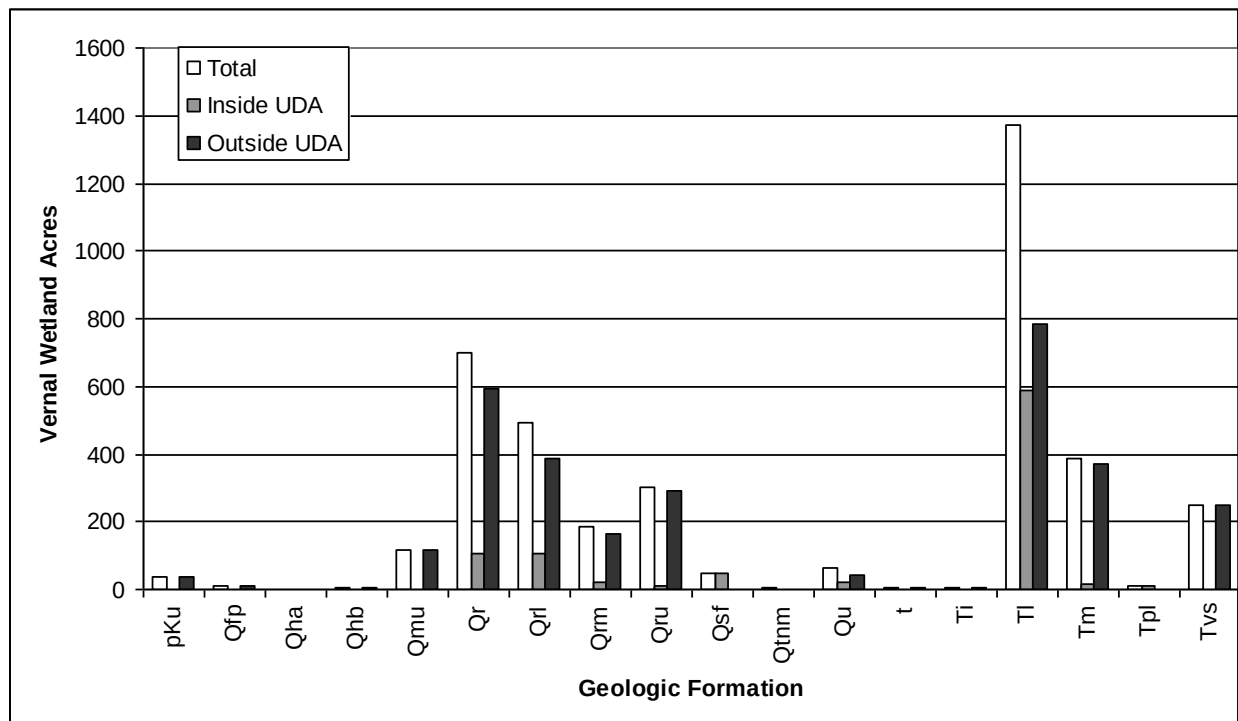


Figure 7 Number of Wetted Acres by Geologic Formation in the SSHCP Study Area. See Table B1-2 for geologic formation names.



APPENDIX B-1 (Continued)

The mean size of vernal pools / wetlands (in acres) for each geologic formation both inside and outside the UDA is summarized in Table B1-5 and illustrated in Figure 8.

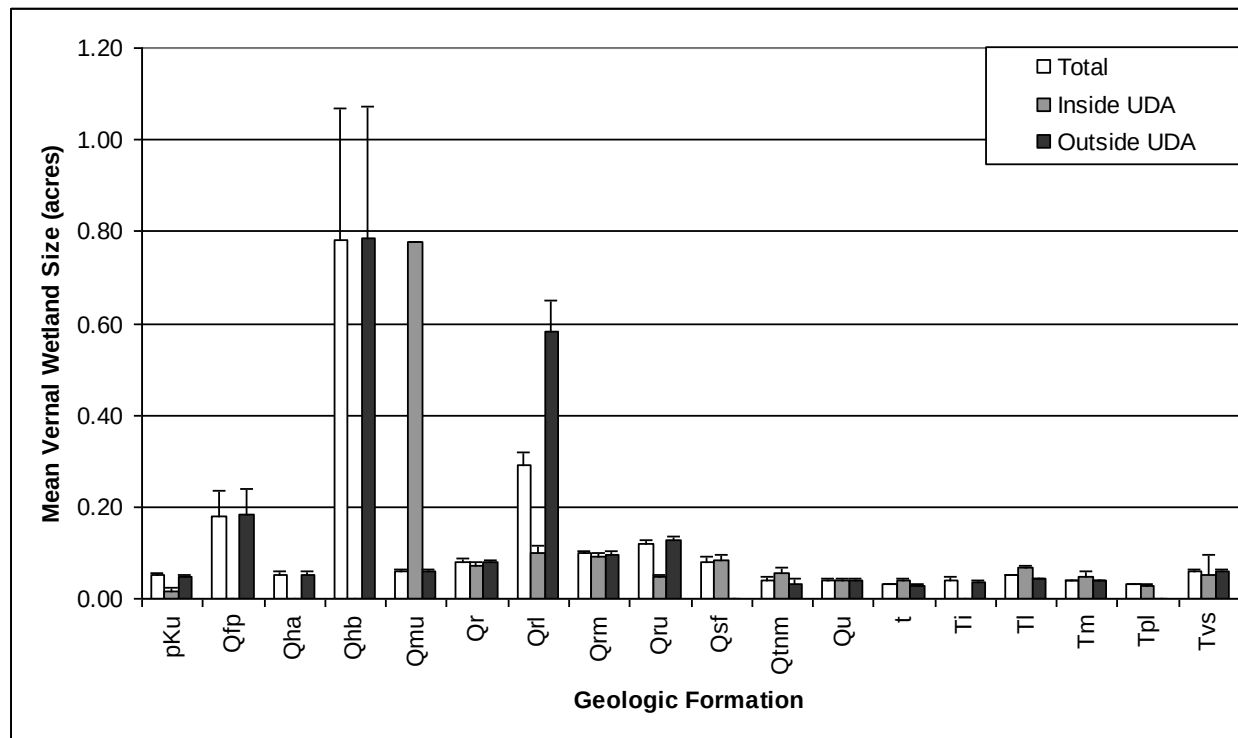
Table B1-5
Mean Vernal Wetland Size (acres) for Geologic Formations within the SSHCP Study Area

Geologic Formation	Total # of Vernal Wetlands	Mean Vernal Wetland Size		Mean Vernal Wetland Size Inside the UDA		Mean Vernal Wetland Size Outside the UDA	
		Mean	SE	Mean	SE	Mean	SE
Laguna (Tl)	26,844	0.05	0.001	0.07	0.004	0.04	0.001
Lower Unit Riverbank (Qrl)	1,719	0.29	0.028	0.10	0.013	0.58	0.067
Riverbank Undivided (Qr)	9,095	0.08	0.006	0.07	0.007	0.08	0.007
Upper Unit Riverbank (Qru)	2,546	0.12	0.008	0.05	0.006	0.13	0.008
Mehrten (Tm)	9,759	0.04	0.001	0.05	0.012	0.04	0.001
Metamorphic Rocks (pKu)	829	0.05	0.005	0.02	0.006	0.05	0.005
Middle Unit Riverbank (Qrm)	1970	0.10	0.006	0.09	0.010	0.10	0.006
Upper Unit Modesto (Qmu)	1888	0.06	0.004	0.78	N/A (one record)	0.06	0.004
Dredge Tailing and Artificial Fill (t)	162	0.03	0.003	0.04	0.005	0.03	0.005
Valley Springs (Tvs)	4,018	0.06	0.003	0.05	0.043	0.06	0.003
Alluvial Floodplain Deposits (Qfp)	59	0.18	0.054	N/A	N/A	0.18	0.054
Undifferentiated Surficial Alluvial Deposits (Qu)	1550	0.04	0.002	0.04	0.003	0.04	0.003
South Fork Gravels (Qsf)	586	0.08	0.011	0.08	0.011	N/A	N/A
Alluvial Deposits, Undivided (Qha)	32	0.05	0.011	N/A	N/A	0.05	0.011
lone (Ti)	89	0.04	0.006	N/A	N/A	0.04	0.006
Turlock Lake (Tpl)	342	0.03	0.003	0.03	0.003	N/A	N/A
Basin Deposits (Qhb)	4	0.78	0.288	N/A	N/A	0.78	0.288
North Merced Gravels (Qtnm)	84	0.04	0.009	0.05	0.013	0.03	0.011
Total	61,576	N/A	N/A	N/A	N/A	N/A	N/A

Abbreviations are: UDA = Urban Development Area.

APPENDIX B-1 (Continued)

Figure 8 Mean (mean + 1 SE) Vernal Wetland Size for All Vernal Wetlands, and Those Inside and Outside the Urban Development Area by Geologic Formation in the SSHCP Study Area. See Table B1-2 for geologic formation names.



Large vernal wetlands (those covering 0.10 or more acres) comprise 10% of the total number of wetlands that occur in the SSHCP Study Area. Table B1-6 gives a summary of the large vernal wetlands and total wetted acres occurring on each geologic formation within the SSHCP Study Area. These large vernal wetlands were further sub-divided into five size categories (Table B1-7) that are illustrated graphically in Figure 9.

Table B1-6

Top 10% (Vernal wetlands greater than 0.1 acres) of Largest Vernal Wetlands and Total Vernal Wetland Acre for Geologic Formations within the SSHCP Study Area

Geologic Formation	Wetland Acres			Number of Vernal Wetlands		
	Total	Inside UDA	Outside UDA	Total	Inside UDA	Outside UDA
Laguna (Ti)	686.5	364.0	322.5	2,088	942	1,146
Lower Unit Riverbank (Qrl)	458.6	82.6	376.0	553	195	358
Riverbank Undivided (Qr)	465.4	66.4	399.0	989	164	825
Upper Unit Riverbank (Qru)	238.5	5.6	232.9	583	20	563
Mehrten (Tm)	186.6	7.8	178.8	636	13	623

APPENDIX B-1 (Continued)

Table B1-6

Top 10% (Vernal wetlands greater than 0.1 acres) of Largest Vernal Wetlands and Total Vernal Wetland Acre for Geologic Formations within the SSHCP Study Area

Geologic Formation	Wetland Acres			Number of Vernal Wetlands		
	Total	Inside UDA	Outside UDA	Total	Inside UDA	Outside UDA
Metamorphic Rocks (pKu)	19.5	0.0	19.5	59	0	59
Middle Unit Riverbank (Qrm)	133.2	15.8	117.4	391	44	347
Upper Unit Modesto (Qmu)	70.1	0.8	69.3	191	1	190
Dredge Tailing and Artificial Fill (t)	1.7	0.7	1.0	10	4	6
Valley Springs (Tvs)	151.9	0.0	151.9	413	0	413
Alluvial Floodplain Deposits (Qfp)	9.7	0.0	9.7	13	0	13
Undifferentiated Surficial Alluvial Deposits (Qu)	28.3	10.3	18.0	122	48	74
South Fork Gravels (Qsf)	32.9	32.9	0.0	82	82	0
Alluvial Deposits, Undivided (Qha)	0.7	0.0	0.7	3	0	3
Ione (Ti)	1.5	0.0	1.5	7	0	7
Turlock Lake (Tpl)	2.4	2.4	0.0	8	8	0
Basin Deposits (Qhb)	3.1	0.0	3.1	4	0	4
North Merced Gravels (Qtnm)	1.8	1.1	0.7	6	4	2
Total	2492.4	590.4	1902.0	6,158	1525	4,633

Abbreviations are: UDA = Urban Development Area.

Table B1-7

Top 10% (Vernal Wetlands Greater than 0.1 acres) of Largest Vernal Wetlands (in 5 Categories) for Geologic Formations within the SSHCP Study Area

Geologic Formation	Number of Large Vernal Wetlands (acres)					
	Total	>4.0	4.0-1.1	1.1-0.7	0.7-0.37	0.37-0.10
		(Inside the UDA / Outside the UDA)				
Laguna (TI)	2088	6/4	48/24	29/32	111/114	748/972
Lower Unit Riverbank (Qrl)	553	3/13	5/64	11/58	20/85	156/138
Riverbank Undivided (Qr)	989	1/8	11/56	6/41	18/92	128/628
Upper Unit Riverbank (Qru)	583	0/3	0/27	2/32	2/85	16/416
Mehrten (Tm)	636	0/2	3/10	1/20	1/73	8/518
Metamorphic Rocks (pKu)	59	0/0	0/2	0/2	0/8	0/47
Middle Unit Riverbank (Qrm)	391	0/1	0/9	5/21	12/51	27/265
Upper Unit Modesto (Qmu)	191	0/0	0/10	1/15	0/20	0/145
Dredge Tailing and Artificial Fill (t)	10	0/0	0/0	0/0	0/0	4/6
Valley Springs (Tvs)	413	0/1	0/18	0/23	0/57	0/314

APPENDIX B-1 (Continued)

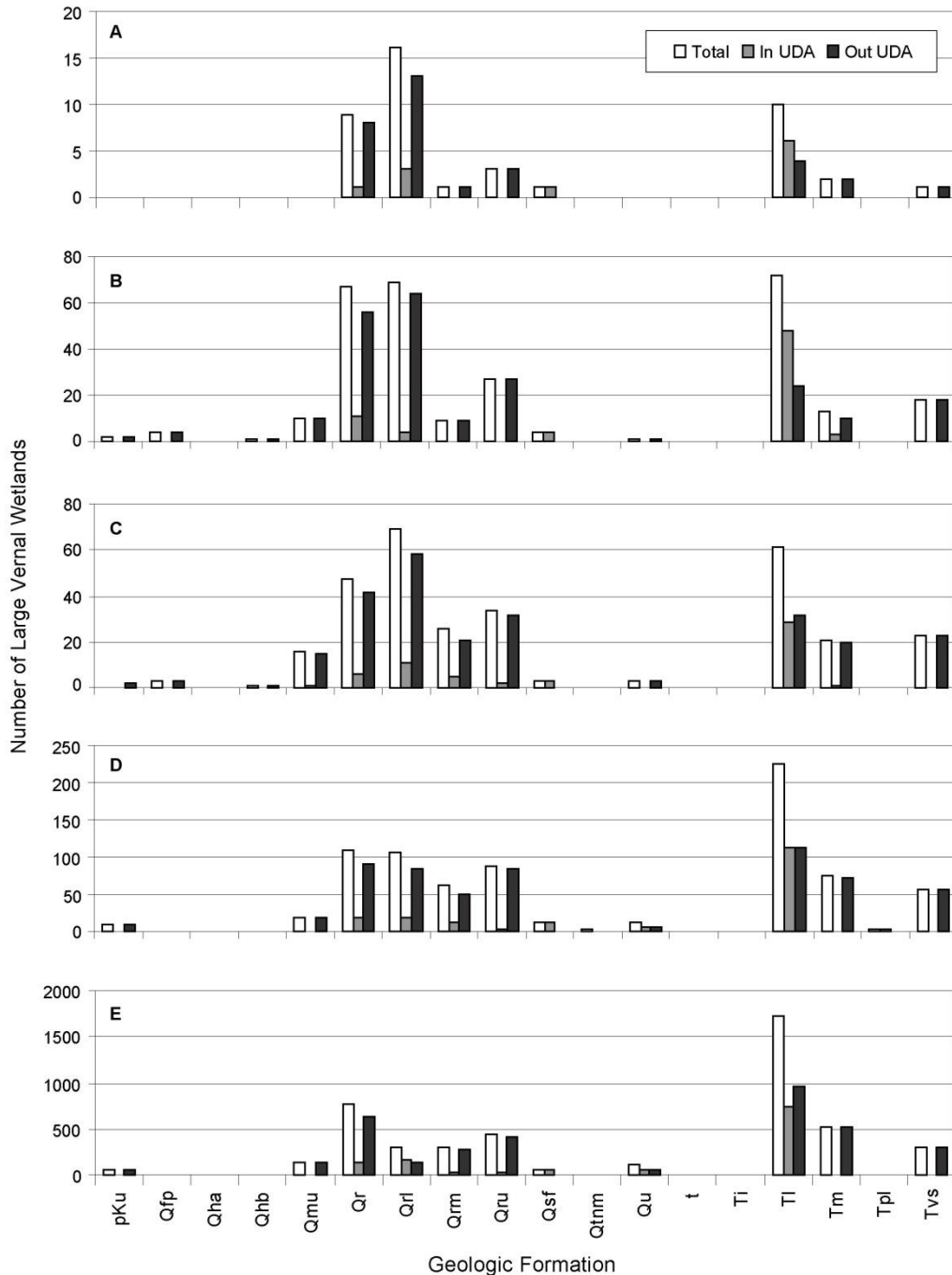
Table B1-7
Top 10% (Vernal Wetlands Greater than 0.1 acres) of Largest Vernal Wetlands (in 5 Categories) for Geologic Formations within the SSHCP Study Area

Geologic Formation	Number of Large Vernal Wetlands (acres)					
	Total	>4.0	4.0-1.1	1.1-0.7	0.7-0.37	0.37-0.10
		(Inside the UDA / Outside the UDA)				
Alluvial Floodplain Deposits (Qfp)	13	0/0	0/4	0/3	0/0	0/6
Undifferentiated Surficial Alluvial Deposits (Qu)	122	0/0	0/1	0/3	5/7	43/63
South Fork Gravels (Qsf)	82	1/0	4/0	3/0	14/0	60/0
Alluvial Deposits, Undivided (Qha)	3	0/0	0/0	0/0	0/0	0/3
lone (Ti)	7	0/0	0/0	0/0	0/0	0/7
Turlock Lake (Tpl)	8	0/0	0/0	0/0	2/0	6/0
Basin Deposits (Qhb)	4	0/0	0/1	0/1	0/1	0/1
North Merced Gravels (Qtnm)	6	0/0	0/0	0/0	1/1	3/1
Total	6158	43	297	309	780	4729
In/Out	1,525/4,633	11/32	71/226	58/251	186/594	1,199/3,530

Abbreviations are: UDA = Urban Development Area.

APPENDIX B-1 (Continued)

Figure 9 Large vernal wetlands (the largest 10%) and their distribution among geologic formations in the SSHCP Study Area and position relative to the Urban Development Area. The graphs represent wetlands in the following large vernal wetland size categories from the top down: (A): >4.0 acres; (B): 4.0-1.1 acres; (C): 1.1-0.7 acres; (D): 0.7-0.37 acres; and (E): 0.37-0.10 acres. See Table B1-2 for geologic formation names.



APPENDIX B-1 (Continued)

The following discussion of the distribution of vernal wetlands in the SSHCP Study Area is organized by geologic formations with the most wetted acres to the formation with the least. Four geologic formations, Laguna, Undivided Riverbank, Mehrten, and Valley Springs contain 80% of the vernal wetlands mapped in the SSHCP Study Area (Table B1-4). The Laguna Formation contains 43% of all mapped vernal wetlands in the SSHCP Study Area. The Mehrten Formation is next in rank (although 5th in terms of overall acreage) bearing 16% of the total number of vernal wetlands, with Undivided Riverbank supporting 15% of the total. Some formations (e.g. Basin Deposits) are relatively minor in terms of number of acres covered, but are important because they support a few very large vernal wetlands.

Average vernal wetland size was calculated for each formation (mean $\pm$ 1SE). Means inside and outside the UDA were compared using a Student's t-test. For most of the formations, there was no significant difference between the means (at the .95 confidence level) inside and outside the UDA. However, means did differ significantly between wetlands inside and outside the UDA on the Metamorphic Rocks Formation, meaning that the larger average size of vernal wetlands outside the UDA is not attributable to random chance.

Deep pools were identified during the mapping process as pools that were at least 50% inundated as of March 15, 2001 (the date the aerial photographs were taken).

SSHCP covered species dependent on vernal pools (Table B1-1) are documented as occurring on 13 of the 18 geologic formations discussed below. Reported occurrences of these species were most often from vernal wetlands on the Laguna Formation. However, some formations (e.g., Lower Unit Riverbank, Riverbank Undivided) containing a smaller percentage of the overall number of vernal wetlands have a relatively high number of covered species occurrences.

3.3.1 Laguna Formation (TI)

The Laguna Formation is the most extensive geologic formation in the SSHCP Study Area with a total of 67,582 acres (28,230 acres inside the UDA and 39,352 acres outside the UDA). It comprises 20% of the total SSHCP land area and is part of the High Terrace Landform that is restricted to the east side of the Central Valley (Smith and Verrill 1998; Jones and Stokes 1990; Reiner and Swenson 2000). The Laguna Formation is composed of interbedded alluvial gravel, sand and silt, deposited from ancient river channels draining from the Sierra Nevada Range, including the Feather, Yuba, American, Cosumnes, and Merced Rivers (Helley and Harwood 1985). It occurs in a band several miles wide running north-south along the eastern half of the SSHCP Study Area. Associated soil families include Redding, Red Bluff and Corning.

The Laguna Formation encompasses 43.5% of the 61,576 total vernal wetlands within the SSHCP Study Area. Of the 26,844 vernal wetlands occurring on this formation, 8,484 are located

APPENDIX B-1 (Continued)

inside the UDA and 18,360 are outside the UDA). The Laguna Formation ranks first in importance in terms of total number of wetlands.

Approximately 34% (1,373 acres) of the total vernal wetland acreage within the entire SSHCP Study Area occurs on the Laguna Formation. There are 587.5 vernal wetted acres within the UDA and 785.5 acres outside the UDA. Mean vernal wetland size (± 1 SE) on the Laguna Formation is 0.05 ± 0.001 acres.

About one third (2,088) of the 6,158 largest vernal wetlands (defined as those ≥ 0.10 acre) mapped within the SSHCP Study Area occur on the Laguna Formation. The Laguna Formation also has the greatest portion (one third) of the top 10% of the largest vernal wetlands (pools >0.10 acres), encompassing a total of 2,088 of the 6,158 large vernal wetlands that occur in the SSHCP Study Area. Over half (55%) of the large wetlands on the Laguna Formation occur inside the UDA; the rest are located outside the UDA.

The Laguna formation has a total of 10,112 deep pools (3,330 inside the UDA and 6,782 outside the UDA). The total acreage of deep pools is 603.3 acres (296.3 acres inside the UDA and 307 acres outside the UDA).

Surveys conducted within the SSHCP Study Area to date have reported all 13 covered species (see Table B1-1) from vernal wetlands on the Laguna Formation (CDFG 2005). Sacramento Orcutt grass and slender Orcutt grass, the only SSHCP “no take species”, are reported exclusively from the Laguna Formation.

3.3.2 Mehrten Formation (Tm)

The Mehrten Formation is made up of eroded, high standing remnants of andesitic volcanic mudflow fans that were deposited during the Pliocene and Miocene, 10-25 million years ago. In the San Joaquin Valley, this stratum overlies the Valley Spring Formation and sits under the Laguna Formation. Vernal pools tend to be located on the western edge of the Mehrten Formation because the eastern portion increases in slope, precluding pool development (Smith and Verrill 1998). There are 26,667 acres of Mehrten Formation within the SSHCP Study Area (3,441 acres inside the UDA and 23,226 acres outside the UDA).

The Mehrten Formation ranks second in total number of vernal wetlands in the SSHCP Study Area, with 9,759 (16%) mapped (298 inside and 9,461 outside the UDA). There are a total of 387 wetted acres associated with the Mehrten Formation (15 acres inside and 372 acres outside the UDA). Mean size (± 1 SE) of vernal wetlands on the Mehrten Formation is 0.04 ± 0.001 acres. Vernal wetlands are similar in average size both inside and outside the UDA.

APPENDIX B-1 (Continued)

The Mehrten Formation encompasses about 10% (636) of the 6,158 largest vernal wetlands inside the SSHCP Study Area. All but 13 of these largest pools are located outside of the UDA.

The Mehrten Formation has a total of 1,829 deep pools (62 inside the UDA and 1,767 outside the UDA). The total acreage of deep pools is 43.9 acres (1.7 acres inside the UDA and 42.2 acres outside the UDA).

Covered species occurring in vernal wetlands on this formation include vernal pool tadpole shrimp, vernal pool fairy shrimp, legenera, and pincushion navarretia.

3.3.3 Riverbank Undivided Formation (Qr)

The Riverbank Undivided Formation covers the third largest area in the SSHCP with a total of 51,425 acres (15,850 acres inside and 35,575 acres outside the UDA). This formation is part of the lower, younger terrace deposited along the entire east side of the Central Valley and the west side of the Sacramento Valley during the Pleistocene (100,000 years ago). Soils with claypans and duripans are common, as are vernal pools (Smith and Verrill 1998). Riverbank Formation is generally confined to the central portion of the SSHCP Study Area and occurs on either side of the Cosumnes River.

The Riverbank Undivided Formation contains the third largest number of vernal wetlands within the SSHCP Study Area with a total of 9,095 (1,466 within the UDA and 7,629 outside the UDA). This is about 15% of the total number of vernal wetlands mapped. The total vernal wetted area of Riverbank Undivided Formation is 701 acres (107 acres within the UDA and 594 acres outside the UDA).

The mean size of vernal wetlands (± 1 SE) on Riverbank Undivided Formation is 0.08 (± 0.006) acres. The Riverbank Undivided Formation supports about 16% of the 6,158 largest vernal wetlands (top 10% largest) mapped within the SSHCP Study Area. Most of the 989 largest pools on this formation occur outside the UDA (174 inside and 825 outside the UDA).

The Riverbank Undivided Formation has a total of 2,462 deep pools (374 inside the UDA and 2,088 outside the UDA). The total acreage of deep pools is 182.8 acres (33.1 acres inside the UDA and 149.7 acres outside the UDA).

Based on surveys conducted within the SSHCP Study Area to date, covered species reported from Riverbank Undivided include the vernal pool endemics vernal pool fairy shrimp, vernal pool tadpole shrimp, mid valley fairy shrimp, as well as California tiger salamander and the vernal pool plant, legenera.

APPENDIX B-1 (Continued)

3.3.4 Valley Springs Formation (Tvs)

The Valley Springs Formation is made up of eroded, high-standing remnants of rhyolitic volcanic mudflow fans that were deposited 20-35 million years ago. Vernal pools tend to be located on the western edge of the formation because the eastern portion increases in slope, precluding pool development (Smith and Verrill 1998). A total of 13,648 acres of Valley Springs Formation occurs on the south-eastern edge of the SSHCP Study Area (91 acres are inside the UDA and 13,557 acres are outside the UDA).

The Valley Springs Formation supports 4,018 vernal wetlands, all but 2 are located outside the UDA. These vernal wetlands total 248 acres. Mean size (± 1 SE) of these vernal wetlands is 0.06 ± 0.003 acres.

The Valley Springs Formation encompasses less than 10% (413) of the 6,158 largest vernal wetlands (≥ 0.01 acres). All of the largest wetlands on this formation are outside the UDA.

The Valley Springs Formation has a total of 1,606 deep pools that are outside the UDA. The total acreage of deep pools is 58.7 acres.

Pincushion navarretia is the only covered species found in vernal wetlands on this formation.

3.3.5 Upper Unit Riverbank Formation (Qru)

The Upper Unit Riverbank Formation is a compacted mixture of granitic sand, silt, and clay with channels of metamorphic gravel, dark brown to red in color. Sediments in this formation are similar to those in the Laguna Formation. This formation developed during the middle to late Pleistocene and covers 28,212 acres (6,295 acres inside the UDA and 21,917 acres outside the UDA) in the central to southern portion of the SSHCP Study Area, overlapping onto the older Laguna Formation to the east and covered by younger alluvium in the western portion.

The 2,546 vernal wetlands associated with Upper Unit Riverbank Formation cover a total of 304 acres. About 90% of these vernal wetlands are located outside the UDA. Mean size (± 1 SE) of vernal wetlands on this formation is relatively large (0.12 ± 0.008 acres). Vernal wetland mean size inside the UDA is 0.05 acres; outside the UDA, mean size is 0.12 acres. Statistically, the difference between the means is not significant ($p = 1.658$).

Of the 6,158 largest vernal wetlands (vernal wetlands ≥ 0.10 acre), 538 are located on the Upper Unit Riverbank Formation. Most of these large pools are located outside the UDA; only 20 occur within the boundaries of the UDA.

APPENDIX B-1 (Continued)

The Upper Unit Riverbank Formation has a total of 726 deep pools (12 inside the UDA and 714 outside the UDA). The total acreage of deep pools is 75.2 acres (0.6 acres inside the UDA and 74.6 acres outside the UDA).

Five covered species have been recorded from vernal wetlands on this formation within the SSHCP Study Area: western spadefoot, California tiger salamander, vernal pool fairy shrimp, vernal pool tadpole shrimp, and mid-valley fairy shrimp.

3.3.6 Middle Unit Riverbank Formation (Qrm)

The Middle Unit Riverbank Formation is similar in composition to the other Riverbank Formations. There are approximately 18,953 acres of Middle Unit Riverbank Formation located within the SSHCP Study Area (5,886 acres inside the UDA and 13,067 acres outside the UDA). This formation occurs in a few disjunct patches in the south-central and north-central parts of the SSHCP Study Area.

There are 1,970 vernal wetlands that occur on The Middle Unit Riverbank Formation (251 inside and 1,719 outside the UDA). These wetlands cover 188 acres, only 23 of which are found inside the UDA. Vernal wetland mean size (± 1 SE) is 0.10 ± 0.006 acres. Average pool size inside and outside of the UDA does not differ significantly ($p = 1.65$).

The Middle Unit Riverbank Formation contains 391 of the 6,158 top 10% largest vernal wetlands. Most of these large vernal wetlands are located outside the UDA.

The Middle Unit Riverbank Formation has a total of 501 deep pools (92 inside the UDA and 409 outside the UDA). The total acreage of deep pools is 50.3 acres (12.3 acres inside the UDA and 38 acres outside the UDA).

SSHCP covered species recorded from this formation include vernal pool tadpole shrimp, mid-valley fairy shrimp, Ricksecker's water scavenger beetle, and legenera.

3.3.7 Upper Unit Modesto Formation (Qmu)

The Upper Unit Modesto Formation is the youngest unit of Pleistocene alluvium consisting of distinct alluvial terraces, some alluvial fans, and abandoned channel ridges (Helley and Harwood 1998). It forms the lowest deposits lying topographically above Holocene deposits along streams in valleys. Streams that still exist today deposited the Modesto Formation between 12,000 and 26,000 years ago. In the SSHCP Study Area, Upper Unit Modesto Formation covers a total of 18,051 acres, bordering the Cosumnes River, Laguna Creek, Skunk Creek, Hadselville Creek, and Browns Creek. Most of these acres are outside the UDA (17,864 acres) and only 185 acres occur within the UDA.

APPENDIX B-1 (Continued)

The Upper Unit Modesto Formation supports 1,888 vernal wetlands covering a total of 117 acres. All but one of these wetlands occurs outside the UDA. The mean size ($\pm$ 1SE) of vernal wetlands on this formation is 0.06 ± 0.004 acres.

The Upper Unit Modesto has 191 of the top 10% of largest vernal wetlands (≥ 0.10 acres). Only one of these large wetlands occurs inside the UDA.

The Upper Unit Modesto Formation has a total of 837 deep pools (1 inside the UDA and 836 outside the UDA). The total acreage of deep pools is 63.8 acres (0.8 acres inside the UDA and 63 acres outside the UDA).

Four covered species are reported to occur in vernal wetlands on this formation: California tiger salamander, mid-valley fairy shrimp, Ahart's dwarf rush, and pincushion navarretia.

3.3.8 Lower Unit Riverbank Formation (Qrl)

There are 53,357 acres of Lower Unit Riverbank Formation (40,273 acres inside the UDA and 13,084 acres outside the UDA), making it the second largest geological formation within the SSHCP Study Area. It is made up of higher riverbank terraces and remnants of alluvial fans. The most extensive exposure of Lower Unit Riverbank is in and around the City of Sacramento and was probably deposited by the American River. The modern Sacramento River is impinging on and eroding this alluvial fan (Helley and Harwood 1985). Lower Unit Riverbank deposits occur in the northwest portion of the SSHCP Study Area.

The Lower Unit Riverbank Formation has 1,719 vernal wetlands within the Study Area (1,055 inside the UDA; 664 outside the UDA). The total area covered by vernal wetlands on the Lower Unit Riverbank Formation is 495 acres, about three-quarters of which, occurs outside the UDA. Mean size ($\pm$ 1 SE) of vernal wetlands on this formation is rather large, nearly 1/3 acre (0.29 ± 0.028 acres). Average vernal wetland size is 0.1 acres inside the UDA and about 0.6 acres outside the UDA. The difference between the means is not statistically significant ($p = 5.36$).

Lower Unit Riverbank has 553 of the 6,158 largest vernal wetlands mapped in the SSHCP Study Area. Of these, 195 occur inside the UDA and 358 occur outside the UDA.

The Lower Unit Riverbank Formation has a total of 353 deep pools (233 inside the UDA and 120 outside the UDA). The total acreage of deep pools is 67.1 acres (29.8 acres inside the UDA and 37.2 acres outside the UDA).

Several occurrences of the SSHCP covered species vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, all vernal pool endemics, are recorded for this formation.

APPENDIX B-1 (Continued)

Legenere, another covered species, has also been reported from Lower Unit Riverbank Formation within the SSHCP Study Area.

3.3.9 Undifferentiated Surficial Alluvial Deposits Formation (Qu)

Undifferentiated Surficial Alluvial Deposits are found on 4,497 acres largely confined to the banks of streams and rivers on the eastern side of the SSHCP Study Area. About a fourth of the area (1,189 acres) is located within the UDA and 3,309 acres are located outside the UDA. This formation derives from various alluvial sources deposited in geologically recent times.

There are 1,550 vernal wetlands on the Undifferentiated Alluvial Deposits Formation: 568 are found inside the UDA and 982 are outside. Total wetted area is 64.1 acres (23.8 acres inside and 40.4 acres outside the UDA). Mean size (± 1 SE) of vernal wetlands on this formation is 0.04 ± 0.002 acres.

The Undifferentiated Surficial Alluvial Deposits Formation has 122 of the 6,158 largest vernal wetlands (1.9%). Forty-eight (48) of these occur within the UDA and 74 occur outside the UDA.

The Undifferentiated Surficial Alluvial Formation has a total of 565 deep pools (243 inside the UDA and 322 outside the UDA). The total acreage of deep pools is 30.2 acres (12.9 acres inside the UDA and 17.3 acres outside the UDA).

Six covered species are reported from vernal wetlands on Undifferentiated Surficial Alluvial Deposits in the SSHCP Study Area: western spadefoot, vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, legenere, and pincushion navarretia.

3.3.10 Metamorphic Rock Formation (pKu)

Exposed metamorphic and granitic rocks are found in the northeastern part of the SSHCP Study Area. These rocks are part of the oldest geologic complex formed before the Cretaceous period, at least 145 million years ago. The Metamorphic Rock Formation covers 7% (24,288 acres) of the total land area in the SSHCP Study Area, of which 86 acres occur in the UDA and 24,201 acres are outside the UDA.

The Metamorphic Rock Formation has 829 vernal wetlands within the SSHCP Study Area, (17 inside the UDA and 812 outside the UDA). Total vernal wetland area for the Metamorphic Rock Formation is 38.2 acres, almost all of which falls outside the UDA. The average size (mean ± 1 SE) of vernal wetlands on this formation is 0.05 ± 0.005 acres. This is the only formation on which average vernal wetland size differs significantly between those inside the UDA and those outside the UDA. Here, average vernal wetland size is statistically significantly smaller inside the UDA (p

APPENDIX B-1 (Continued)

= 0.002). The Metamorphic Rock Formation contains 59 of the 6,158 largest vernal wetlands (≥ 0.10 acres) in the SSHCP Study Area. All of these large wetlands occur outside the UDA.

The Metamorphic Rock Formation has a total of 213 deep pools outside the UDA. The total acreage of deep pools is 6 acres.

Vernal pool fairy shrimp is the only SSHCP covered species recorded from the Metamorphic Rock Formation at the time of this report.

3.3.11 South Fork Gravels Formation (Qsf)

South Fork Gravels form a broken belt of rounded pebbles and cobbles in a matrix of coarse sand that extends in a northeasterly direction in the center of the UDA. The age of this deposit has not been determined, but it is thought to be older than the Laguna Formation. South Fork Gravels cover a total 3,975 acres within the SSHCP Study Area (1.2% of total land area), all of which are inside the UDA.

The 586 vernal wetlands on the South Fork Gravels Formation occupy a total of 48.8 acres. Mean vernal wetland size (± 1 SE) is 0.08 ± 0.011 .

The South Fork Gravels Formation has 82 of the 6,158 vernal wetlands 0.1 acre or larger. All are located within the boundaries of the UDA.

The South Fork Gravels Formation has a total of 143 deep pools inside the UDA. The total acreage of deep pools is 18.8 acres.

Vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, Ricksecker's water scavenger beetle, and legenera are covered species reported from the South Fork Gravels Formation in the SSHCP Study Area.

3.3.12 Turlock Lake Formation (Tpl)

The Turlock Lake Formation is part of the high terrace on the east side of the Central Valley (Smith and Verrill 1998) that formed about a million years ago. It is made up of slightly cemented sand, gravel and silt occurring as a thin layer over the Laguna Formation in the upper central portion of the SSHCP Study Area. The Turlock Lake Formation covers a total of 2,095 acres, all of which are inside the UDA.

The Turlock Lake Formation has 342 vernal wetlands (9.5 wetted acres) within the SSHCP Study Area. Mean size (± 1 SE) of these vernal wetlands is 0.03 ± 0.003 acres. Eight of the 342 vernal wetlands on Turlock Lake Formation are 0.10 acres or larger. All of these large wetlands occur within the UDA.

APPENDIX B-1 (Continued)

The Turlock Formation has a total of 55 deep pools inside the UDA. The total acreage of deep pools is 2.2 acres.

SSHCP covered species reported from the Turlock Lake Formation to date are western spadefoot, vernal pool fairy shrimp, and vernal pool tadpole shrimp.

3.3.13 Dredge Tailing and Artificial Fill Formation (t)

The Dredge Tailing and Artificial Fill Formation consists of rows of large cobble, gravel, sand, silt, and clay deposited along riverbanks as a result of gold mining undertaken during the 1800's. This formation covers 14,527 acres, 4.2% of the total land area of the SSHCP. Most (12,735 acres) of the land covered by dredge tailings and artificial fill occurs within the UDA in the northern portion of the SSHCP Study Area and 1,791 acres occur outside the UDA.

Less than one percent (162) of the mapped vernal wetlands occur on this formation (64 inside and 98 outside the UDA). These vernal wetlands cover about 5 acres; half of which occur within the UDA and the other half outside the UDA. Average vernal wetland size (mean $\pm$ 1SE) is 0.03 ± 0.003 acres. There is no significant difference between the mean size of wetlands inside compared with outside the UDA.

Ten of the 6,158 largest pools occur on this formation, 4 of them inside and 6 outside the UDA.

The Dredge Tailings and Artificial Fill Formation has a total of 75 deep pools (10 inside the UDA and 65 outside the UDA). The total acreage of deep pools is 2.2 acres (0.8 acres inside the UDA and 1.4 acres outside the UDA).

No SSHCP covered species have been reported from this formation to date.

3.3.14 Ione Formation (Ti)

The Ione Formation is composed of three distinct layers: quartz sandstone overlying white clay, with gray or blue clay below. This developed during the Eocene (40-50 million years ago) when the Central Valley was covered by inland sea. Ione formation is exposed in the eastern portion of the SSHCP Study Area.

It covers a total of 2,956 acres (61 acres are inside the UDA and 2,895 acres are outside the UDA).

Eighty-nine vernal wetlands (3.1 wetted acres) have been mapped on Ione Formation. All fall outside the boundary of the UDA. Vernal wetland mean size ($\pm$ 1 SE) is 0.4 ± 0.006 acres. Of the 6,158 large vernal wetlands (≥ 0.1 acres), 7 occur on the Ione Formation. All of these large vernal wetlands are outside the UDA.

APPENDIX B-1 (Continued)

The Ione Formation has a total of 32 deep pools outside the UDA. The total acreage of deep pools is 0.8 acres.

There are no SSHCP covered species reported from this formation at this time.

3.3.15 North Merced Gravels (Arroyo Seco Gravel) Formation (Qtnm)

The North Merced Gravels Formation is made up of coarse, round pebbles and cobbles derived from dark metamorphic rocks that were laid down by streams and rivers draining the Sierra Nevada 1-3 million years ago. In the SSHCP Study Area, this formation occurs as a thin layer that overlies very high terraces of Laguna Formation sediments, covering 561 acres (500 acres are inside the UDA and 61 acres are outside the UDA).

There are 84 vernal wetlands on the North Merced Gravels Formation; 41 of these are found inside the UDA and 43 are outside the UDA, for a total of 3.6 wetted acres. Average size (mean $\pm$ 1 SE) of vernal wetlands mapped on this formation is 0.04 ± 0.009 acres.

Six of the 6,158 largest vernal wetlands (4 inside and 2 outside the UDA) occur on North Merced Gravels within the Study Area.

The North Merced Gravels Formation has a total of 45 deep pools (9 inside the UDA and X outside the UDA). The total acreage of deep pools is 2.6 acres (1.2 acres inside the UDA and X acres outside the UDA).

Boggs Lake hedge-hyssop is the only covered species reported from North Merced Gravels in the SSHCP Study Area at this time.

3.3.16 Alluvial Floodplain Deposits (Qfp)

The Alluvial Floodplain Deposits Formation is made up of fine sand, silt, and clays deposited down during the current epoch. It covers 9,733 acres, all of it outside the UDA, primarily in the southwestern portion of the SSHCP Study Area. There are 59 vernal wetlands on this formation covering a total of 10.9 acres.

Vernal wetlands on this formation are relatively large. Mean wetland size ($\pm$ 1 SE) is 0.18 ± 0.054 acres. Thirteen of the largest 10% of vernal wetlands occur on this formation; about half of these are one acre or larger.

The Alluvial Floodplain Deposits Formation has a total of 21 deep pools outside the UDA. The total acreage of deep pools is 2 acres.

APPENDIX B-1 (Continued)

Dwarf downingia and legenera are the only covered species reported from vernal wetlands on Alluvial Floodplain Deposits within the SSHCP Study Area to date.

3.3.17 Undivided Alluvial Deposits (Qha)

Undivided Alluvial Deposits are composed of cobbles, gravel, sand, silt and clay. This formation occurs on less than 1% of the total SSHCP Study Area. Of the 3, 419 acres mapped, 838 acres occur inside the UDA and 2,582 acres occur outside the UDA in discrete patches along the boundaries of the SSHCP Study Area. There are 32 vernal wetlands on this formation that cover a total of 1.6 acres, all outside the UDA.

Mean area (± 1 SE) of the vernal wetlands on Undivided Alluvial Deposits is 0.05 ± 0.011 acres. Three of the top 10% largest vernal wetlands occur on this formation. All three are found outside the UDA.

The Undivided Deposits Formation has a total of 9 deep pools outside the UDA. The total acreage is 0.2 acres.

No covered species have been reported from this formation to date.

3.3.18 Basin Deposits (Qhb)

Basin Deposits occur as unconsolidated clay, silt, and other fine material that formed in sink areas during the Holocene epoch. This recent formation is found in the eastern-most corner of the SSHCP Study Area and covers a total of 663 acres (590 acres inside and 73 outside the UDA).

Four vernal wetlands were mapped on this formation; these cover a total of 3.1 acres, all outside the UDA. Average size (mean $\pm$ SE) of vernal wetlands on Basin Deposits is quite large: 0.78 ± 0.228 acres. Each of the four wetlands on this formation is 0.10 acres or larger.

The Basin Deposits Formation has a total of 2 deep pools outside the UDA). The total acreage of deep pools is 2.4 acres.

No covered species have been reported from this formation to date.

APPENDIX B-1 (Continued)

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4 THREATS TO HABITAT AND AQUATIC RESOURCES

It is impossible to determine the acreage of vernal pool complexes, the number of vernal pools, or the distribution of types of vernal pools that once occurred in pre-settlement California. Dahl (1990) estimates that California has lost 95% of its pre-settlement wetlands (including vernal pools), more wetland loss than any other state in the Country. Holland (1998) reports a loss of approximately three million acres (~75%) of vernal pool complexes since the European settlement of California. He estimates that, as of July 1997, less than one million acres of mostly fragmented complexes remain. It was further estimated that since 1987, Merced County has lost 30,317 acres of vernal pool habitat, and that between 1972 and 1993 Sacramento County lost 30,512 acres (Holland 1998). Figures for total losses of vernal pool habitat statewide since 1997 are not available. However even at a conservative estimated loss rate of 1.5% per year (it may be greater considering current 50-year build-out projections for Merced, Sacramento, Solano, and Placer Counties), the estimated one million acres remaining in 1997 will be reduced by one-half in 46 years, down to just 12% of the pre-settlement California vernal pool acreage (Keeler-Wolf et al. 1998).

Vernal pool habitat remaining in California is further threatened by direct loss and by degradation resulting from residential and industrial development, agricultural land-use conversion, habitat fragmentation, hydrological alteration, invasive plant species, inappropriate livestock and vegetation management, non-point source water and air pollution and climate change.

4.1 Urban and Industrial Development

The greatest losses of California vernal pool habitat have resulted primarily from land-use conversion to irrigated agriculture, starting in the latter part of the 19th Century (see Section 4.2), and more recently, to residential and industrial development. Development remains the main threat to the continued existence of functioning vernal pool landscapes in the Central Valley and elsewhere in California (Jokerst 1993; Bauder et al. 1997; Keeler-Wolf et al. 1998).

It is important to note that Sacramento and Placer Counties together contain the majority of the vernal pool acreage existing in the Southeast Sacramento Valley Vernal Pool Bioregion. This Bioregion encompasses the majority of the State's Northern Hardpan Vernal Pool type as well (CDFG 1998). Most of the Volcanic Mudflow Vernal Pool type in this Bioregion has already been lost to development (Keeler-Wolf et al. 1998). Considering past losses, projections for development, and the high quality of some of the vernal pool habitat remaining in Sacramento and Placer Counties, the Southeast Sacramento Valley Vernal Pool Bioregion is one of the more ecologically important regions, and one of the most threatened.

Land development threatens the remaining vernal pool ecosystem directly through destruction and fragmentation of habitat. Loss of habitat, however may also indirectly affect the remaining areas by increasing the likelihood of other threats (e.g. habitat fragmentation, hydrological alteration, invasion by noxious species, changes in land management options/practices, pollution, inadequate mitigation measures, etc.).

4.2 Agricultural Conversion

Along with Urban/Industrial development, conversion to intensive agriculture has been a leading threat to vernal pool landscapes. Loss of vernal pool habitat began in earnest in the latter decades of the 19th Century, as agricultural development in the Central Valley spread from the deep-soil of fertile riverine floodplains onto the more poorly-drained soils of the higher-older alluvial fans and terraces (Smith and Verrill 1998). Common methods used to improve cultivation conditions in these vernal pool landscapes included leveling of mound-swale topography, excavation of drainage ditches to lower perched water tables, and ripping and blasting of subsoil horizons for improved water drainage. With the later advent of large-scale water delivery and drainage systems, conversion to irrigated agriculture expanded further still (Smith and Verrill 1998).

Until recently, most of the large tracts of middle and upper terrace-vernal pool habitat in the Central Valley remained intact as part of large-scale annual-pasture livestock ranches which, in most cases, have not significantly altered the landscape. In recent years, however, conversion of these otherwise marginal ranchland soils to vineyards has been increasing and has become a leading threat to vernal pools in the Southeastern Sacramento Valley Vernal Pool Bioregion (Keeler-Wolf et al. 1998).

4.3 Habitat Fragmentation

Fragmentation of vernal pool habitat results from a variety of causes and occurs at a range of spatial and temporal scales. This fragmentation reduces the spatial and ecological continuity within a given land unit (see discussion of ecological connectivity Section 1.4 of this report). Habitat fragmentation is an ongoing and cumulative threat to the vernal pool ecosystem.

It is important to consider the spatial scale of potential effects of developments. For example, Forman and Deblinger (2000) estimated the “road-effect zone” for a busy four-lane highway in Boston, Massachusetts to be an average of 600 meters in width and asymmetric. They suggest that avoidance of roads due to vehicle traffic is probably of more ecological impact to biota than the more evident roadkills. Plants that use animals for dispersal of their propagules are also affected by animal-road avoidance. Fragmentation of natural habitats by roads tends to fragment continuous populations into subpopulations, making each subpopulation more vulnerable to local extinction events due to decreased emigration, immigration and gene flow (Forman and

APPENDIX B-1 (Continued)

Alexander 1998). Roads and other fragmenting intrusions also lessen the visual aesthetic appeal of a natural landscape.

At the larger landscape scale, change in regional abundance and distribution of vernal pool habitat may also change the migration and habitat use patterns of waterfowl and shorebirds on the Pacific Flyway, which in turn also affects meta-population dynamics of numerous organisms and alters multiple landscape-scale ecological functions.

Considered at smaller scales, habitat fragmentation can result from placement of roadbeds, railroad tracks, walls, utility corridors or other developments within vernal pool complexes. These types of intrusions can prevent the California tiger salamander or western spadefoot from completing their necessary seasonal migrations to and from rodent burrows in adjacent uplands. In addition to altering the vernal pool hydrologic cycle, interruption of hydrologic interconnectivity by these types of developments can disrupt dispersal of plant seeds and invertebrate cysts/eggs, thus manifesting changes in long-term meta-population dynamics. Fences that limit the movement of livestock through the landscape may also affect meta-population dynamics, since livestock are also implicated in the transport of seeds, cysts and eggs.

One significant negative aspect of habitat fragmentation is the increased edge effect to which remaining preserved vernal pool habitat areas are subject. As remaining habitat areas diminish in size, the ratio of vulnerable edge to preserved interior area increases. Ecological consequences arise because, as this ratio increases, any given interior point (vernal pool or organism) is closer to potential threats existing outside of the preserve boundary. Concomitant with increased edge effect are increased vulnerability to stochastic disturbances, pollution, and increased vulnerability to invasions by non-native plant and feral animal species. Edge effect can be minimized for vernal pool/annual grassland preserves by maximizing the size of the preserve areas (in contrast to creating more numerous smaller preserves), and by designing preserves that are as round in shape as possible. All other factors considered equal, the best shape for an ecological preserve is a circle, and the least preferable is a long narrow rectangle.

Fragmentation ultimately leads to smaller and more numerous tracts of habitat areas, which may be proportionally more difficult to regulate, monitor and manage in a consistent, efficient, and economical fashion. In addition, smaller, more numerous preserves are more likely to be surrounded by developed residential and/or industrial areas that not only present more types and more frequent threats, but may also be less attractive to migratory waterfowl and shorebirds. For these and other reasons fragmented habitats are less likely to maintain complex ecosystem processes and species populations over time.

4.4 Invasive Non-native Plants and Animals

In general, vernal pool habitat is excessively demanding for most non-native plant and animal species; however, a number of invasive species exist which are documented as potential threats to vernal pool habitat. In addition, invasive species not yet known to be a threat to California vernal pools may be introduced in the future (see Data Gaps Section 7). Invasive species in both vernal pool basins and in surrounding uplands can negatively affect vernal pool habitat in a variety of ways, ultimately changing ecological functions and negatively affecting desirable species.

Non-native annual grasses of Mediterranean origin now dominate the uplands associated with vernal pool complexes in California. The transition from native vegetation to exotics began with European settlement and was hastened by years of drought and overgrazing during the late 1800s. Some suggest that rapid evapo-transpiration of water and built-up thatch from non-native grass species (e.g., foxtail chess, Italian wildrye, Mediterranean barley, Medusa-head grass, soft chess) may indirectly affect vernal pool species by lessening the amount of water entering the system through surface and subsurface flow (Marty 2003; Robins and Vollmar 2002). The effects of thatch buildup in uplands may negatively affect obligate vernal pool bee pollinators as well. Thick stands of mulch may also impede juvenile California tiger salamanders and western spadefoots during their migrations from their aquatic pool habitat to the upland areas and burrows used for summer activity and aestivation. Barbed awns and seed coats on non-native grasses can also injure or kill mammals by becoming lodged in their ears, eyes, throats and fur.

Italian wildrye and Mediterranean barley are two non-native facultative wetland species that typically dominate disturbed seasonal wetlands and invade smaller, more ephemeral vernal pool types. In heavy clay soils and in non-grazed systems, these two grasses can encroach upon the pool margins, resulting in a simplified pool edge habitat with diminished native plant diversity (Robins and Vollmar 2002).

Other weedy hydrophytic species reported as growing within vernal pools in the Sacramento Valley include lippia (*Phyla nodiflora*), swamp pricklegass (*Crypsis schoenoides*), European mannagrass (*Glyceria declinata*), field bindweed (*Convolvulus arvensis*), common unicorn plant (*Proboscidea louisianica*), Bermuda-Grass (*Cynodon dactylon*) and paradox canary-grass (*Phalaris paradoxa*). Cocklebur (*Xanthium strumarium*), a native species, can also dominate vernal pools (Schlising, Unger pers. comm.; Dittes pers. obs.).

Non-native mammals inhabiting grasslands and vernal pool complexes in California include the domestic cat, domestic dog, feral pig, Norwegian rat, black rat, house mouse and perhaps most recently, ferrets. These animals prey on native species, thus decreasing population viability. They also have the potential to spread diseases and parasites to other mammals within the area. Non-native birds such as the European house sparrow and European starling are also invading annual

grasslands and vernal pool complexes. These birds compete with native species for foraging areas and nesting sites.

Non-native amphibians known to invade vernal pools and seasonal wetlands include the introduced tiger salamander (*Ambystoma tigrinum*) and bullfrog (*Rana catesbiana*). Although bullfrogs require permanent bodies of water to complete their life cycles, they can migrate through vernal pools, where they feed voraciously on native amphibians and crustaceans. In general, native amphibians do not occur in water bodies occupied by bullfrogs and non-native fishes. The introduced tiger salamander (*Ambystoma tigrinum*) was introduced as fish bait and now several populations have become established in California. The species has been reported to be hybridizing with California tiger salamander (Schaffer et al. 1993).

4.5 Livestock Grazing

In general, livestock grazing under appropriate conditions is thought to be compatible with vernal pool ecosystems, and in many cases even beneficial (Pyke and Marty 2005; Marty 2003; Vollmar and Robins 2002; Griggs 2000). In other cases though, livestock grazing can be deleterious when an incompatible grazing regime is used. Grazing is cited as a threat to a variety of sensitive vernal pool organisms at a number of Central Valley locations (CDFG 2003).

Complete absence of livestock grazing can be disadvantageous to vernal pools in several ways. Barry (1998) concluded that complete rest from grazing: allows upland species to encroach upon pool edges (species in centers of pools are less affected); can cause decreased water runoff and increased soil infiltration, percolation and water storage capacity due to increased vegetation; and can result in decreased diversity around pools. Marty (2003) found that aquatic invertebrate species richness was highest in grazed vernal pools, likely resulting from longer inundation periods due to higher soil compaction.

Some showy vernal pool plants (e.g., *Blennosperma*, *Downingia*, *Lasthenia*, *Limnanthes*) require the pollination services of specialist bees to reproduce (Thorp 1976, 1990; Thorp and Leong 1995, 1996, 1998). These bees nest in the soil of uplands within vernal pool complexes. Therefore, vernal pool conservation must consider nesting requirements of oligolectic (pollen specialist) bees to ensure longevity of some vernal pool plants. Effects of grazing on specialist bees are not known. Given that soil disturbance and compaction in grasslands is a well-known consequence of livestock grazing, with ecological affects varying by site (Duffey et al. 1974), perturbations to bee nests and potential nesting sites are possible. Conversely, these specialist bees may not fare well in situations where excessive thatch, particularly from Medusa-head grass, results because of too little grazing. Soil types, vegetation composition, number and type of livestock, grazing duration, and seasonal periods are all factors affecting soil compaction and erosion by livestock.

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Other negative potential effects of livestock grazing on vernal pool habitats result more from inappropriate timing of the grazing regime, than from the intensity of the grazing. For example, Orcutt grass flowers and sets seed during the late spring and summer months. Grazing of Orcutt grass -occupied pools at this time can reduce or eliminate the season's reproductive effort, and over time can exhaust the soil seed bank. Grazing with livestock while the pool is still inundated in the late fall, winter, and early spring months allow plants in the juvenile life stage to escape grazing and trampling impacts. Similarly, grazing in the very late summer and fall months, after seeds have matured and dried, also allows for escape from these negative pressures (Stone et al. 1988). Grazing during the migration of California tiger salamander and western spadefoot can lead to mortality by trampling.

Influence of livestock grazing on the water chemistry of vernal pools has not received direct investigation, although Robins and Vollmar (2002) provide a good review of what is currently known. Excessive livestock use can result in nutrient overloading of vernal pool basins via input of feces and urine. Under these conditions, algal blooms proliferate and eutrophication (oxygen depletion) ensues. Excessive growth of algae also limits light penetration into the water column, limiting growth of plant seedlings and potentially affecting ecology of the invertebrate community. Livestock grazing may also result in the removal of nitrogen from the vernal pool ecosystem by conversion of plant material. Livestock congregating around pool edges may increase soil erosion and pool turbidity, potentially smothering amphibian larvae.

For these and potentially other reasons, overgrazing, under grazing and improperly timed livestock grazing can negatively affect the vernal pool species and vernal pool ecosystems.

4.6 Hydrologic Alterations

As described in Section 1.2 and 1.3 of this report, timing of the four phases of the vernal pool hydrological cycle is considered to be the over-riding factor in determining the biological structure and ecological functions of the vernal pool ecosystem. It follows then that any alteration of a sub-watershed that affects the timing of the hydrological cycle has potential to affect the ecological integrity of the vernal pools present there.

Water added to the system resulting in prolonged inundation and/or waterlogged-terrestrial phases could push the vernal pool hydrology and biota away from the unique vernal pool type and towards that of the common seasonal marsh. Alterations of this type can be observed where construction of berms (e.g., stockponds) and/or obstruction of swales by roadbeds, railroad tracks and canal berms have resulted in the impoundment of water in vernal swales or an increase in pond depth. Vernal pools can also shift toward a seasonal marsh inundation regime as a result of increased precipitation runoff flowing from nearby developed impermeable surfaces, from irrigated landscaping, and from irrigated agriculture.

Conversely, water removed from the vernal pool system resulting in abbreviation of the inundated and/or waterlogged-terrestrial phases can lead to a shift towards the less specialized seasonal wetland type that is dominated by low diversity of mostly non-native plant species and generalist invertebrates. Reduction of duration of the inundated and/or waterlogged-terrestrial phases may result from interruption of flow into pools in settings where swales contribute to pool basin hydrology. Since the hydrological cycle is linked to the surrounding upland soil profile (Hains and Stromberg 1990), disturbances to the surrounding upland soil profile within a watershed containing vernal pools may alter the vernal pool ecological function as well.

Degradation of vernal pools resulting from hydrological alteration are cited as threats at a number of recorded locations, including the Phoenix Field and Phoenix Park Preserves, at other sites in Sacramento County, and elsewhere in the state (CDFG 2003; USFWS 1994; Fisher and Schaffer 1996; Stone et al. 1988; Clark et al. 1998; Dittes pers. obs.).

4.7 Fires

Grassland fires are considered to be a beneficial part of the natural cycle of historic California grassland landscapes and are generally not considered a threat to vernal pools and vernal pool ecosystems. Contemporary annual grassland communities are commonly managed with fire to control the buildup of thatch and the cover of exotic species, namely Medusa-Head Grass and Yellow Star Thistle (Griggs 2000; Mawdsley 2000). However, there are cases where fire carries through vernal pools during the dry summer and fall months, impacting the rare late blooming Orcutt Grasses (Schlising pers.comm.). Removal of upland vegetation (by fire or grazing) may also increase grazing pressures on plants remaining within pools or enclosures. For example, grasshoppers were observed eating large amounts of the rare Orcutt Grass after adjacent uplands were burned and heavily grazed at the Vina Plains Preserve in Tehama County (Schlising pers. comm.).

Management activities associated with fire control activities (e.g., plowing or scraping fuel breaks) may impact vernal pools and vernal pool complexes. Sacramento Orcutt grass pools at the Keifer Landfill have fuel breaks constructed through them along Grant Line Road and along Keifer Boulevard. These fuel breaks may directly affect plants and animals and may also alter the hydrology both the impacted pool and surrounding pools.

4.8 Recreation Activities

Recreation is not commonly considered when discussing threats to vernal pools. Since vernal pools are aesthetically appealing for only a short part of the year, unlike riparian areas that have living vegetation and water for a significant part of the year, they have been described as having an

APPENDIX B-1 (Continued)

“image problem” (Zedler 1987). Impacts from recreation may become more of a concern as more development occurs and more preserves are established in close juxtaposition with housing tracts.

Vernal pool impacts resulting from recreation activities are reported from the Phoenix Park Preserve in Sacramento County (Clark et al. 1998). In this urban-natural area interface, trampling from foot, horse and bicycle traffic within the highly accessible Preserve was reported to compact soils, eliminate plant cover where trails came close to pools, and disturb plants and wildlife. In addition litter accumulation is also cited as a problem (CDFG 1983; Clark et al. 1998). Recreational off-road vehicle use during the wet season can create large ruts and reduce vegetative cover; this activity has been observed in Butte, Tehama and Sacramento Counties (Dittes per. obs.). Uncontrolled dogs and cats may disturb wildlife as well.

4.9 Pollution

A variety of point and non-point-source pollutants enter the vernal pool landscape via overland and subterranean flow of water, and atmospheric pollution can enter in precipitation and in the form of dust. Wind-blown trash accumulation and even illegal dumping of household garbage and garden waste has also been cited as threats in some vernal pool systems (CDFG 2003; Clark et al. 1998).

4.10 Water Pollution

One of the nutrients primarily responsible for eutrophication of freshwater systems is phosphorous, which is often bound to soil particles from agricultural land. Approximately 65 percent of the sediment washed into U.S. streams, rivers and lakes is from cropland, pastures and rangeland. Non-point sources of pollution in urban and residential areas include failing septic systems, septic system additives, improper disposal of household chemicals, storm water runoff, construction activities, and inappropriate use of fertilizers and pesticides (Master et al. 1998).

Impermeable surfaces such as asphalt, concrete, and roofing increase the intensity of storm water runoff and provide a path for runoff laden with sediment, heavy metals, oil and oxygen-demanding organic matter (Master et al. 1998). Nutrients or toxicants are dissolved in water and enter streams where they may move downstream, accumulate in deposits and be ingested by organisms (NRC 1992). Sacramento County (1993) stated that “urban storm water runoff discharges contain non-point source pollutants that lower the quality of receiving waters” in Sacramento County, and indicated that pasture runoff could also serve as a source of “surface water quality degradation”.

Pesticide residues in water and soil are well known to have various deleterious effects on non-target organisms (Davidson 1979; Hurlbert et al. 1972; Simon and Buikema 1997; Wurster 1968), although specific studies addressing the effects of pesticides in vernal pool ecosystems are

APPENDIX B-1 (Continued)

lacking. A recent study in the Sacramento area (Roseville) reported that urban runoff containing pyrethroids (the active ingredients found in most insecticides available for residential use) was responsible for sediment toxicity in about half the number of samples collected. In some cases, sediment toxicity caused total or near total (>90%) mortality when exposed to the aquatic amphipod species *Hyalella azteca* in laboratory exposures (Weston et al. 2005).

Herbicides are commonly used to control unwanted plants, native or otherwise. Duffey et al. (1974) recommend that herbicides should not be used on grasslands managed for nature conservation. The effect of herbicides on vernal pool organisms and ecology has not been quantified. However, Clark et al. (1998) observed that plants were killed in vernal pools that received herbicide-laden runoff from nearby areas. Enough seeds apparently were stored in the soil seed bank to allow plants to become reestablished the following year, but continued runoff containing herbicides would likely limit the ability of the vernal pool flora to recover. Similarly, herbicide runoff from the treated ground around a wooden utility pole in Eastern Merced County was observed to result in complete lack of vegetation in an adjacent vernal pool that received the runoff (Dittes pers. obs.)

APPENDIX B-1 (Continued)

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5 CLASSIFICATION OF VERNAL POOLS / WETLANDS

Vernal pools/wetlands have been variously classified, depending on the scope and purposes of the particular effort. Classification systems developed by various regulatory agencies and consultants for vernal pools and seasonal wetlands, their defining parameters, and applicability to the SSHCP are summarized in the following discussion. These classification systems are variously based on landforms, geologic formations, soils, hydro-geomorphology, composition of vegetation, or combinations of these in the context of geographic setting (Butterwick 1998; Cowardian et al. 1979; Holland 1986; Jones & Stokes 1990; Reiner and Swenson 2000; Sawyer and Keeler-Wolf et al. 1998; Vollmar 2002).

5.1 Previous Vernal Pools/Wetlands Classification in Sacramento County and the SSHCP Study Area

The first comprehensive classification of Sacramento County's vernal pool habitat was based on association of vernal pool complexes with geologic landform (Jones and Stokes 1990). Landforms result from specific episodes of geologic activity and are physically recognizable features of the earth's surface that have distinguishable shape, range, and composition (Smith and Verrill 1998). According to this system, Sacramento County vernal pools fall into one of four categories: Young-Terrace Pools (Riverbank Formation), Old Terrace Pools (Laguna and Arroyo Seco Gravels), Mudflow Pools (Mehrten and Valley Springs Formation), or Drainage way (recent alluvial deposits over other formations). These four landforms are further subdivided by specific geologic surficial deposits (or formations) based on differences in age, parent material, soil profile development, texture, geomorphic expression, lithology, stratigraphy, induration, and depositional environment (Helly and Hardwood 1985).

Although it was noted that vernal pool habitat varies according to landform association, no quantifiable data were used to describe the patterns of variance. Qualitative generalizations regarding vernal pool shape, depth, size and surface drainage were provided for each of the soil series present in the County (Jones and Stokes 1990). It was acknowledged however, that substantial fieldwork is required before justifying the use of soil series as a primary category of vernal pool classification.

The Nature Conservancy (TNC) modified and applied this landform and geologic formation-based classification system to their Cosumnes River Watershed Project (Reiner and Swenson 2000). As part of this effort, vernal pools in the southeast SSHCP Study Area were categorized according to the following landform categories: Low Terrace Grasslands (Riverbank), High Terrace Grasslands (Laguna), Terrace Drainageway Grasslands (Modesto/Riverbank), and Mudflow Grasslands (Mehrten and Valley Springs Formations).

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These landform categories were used by TNC in conjunction with soil maps and vernal pool density maps to qualitatively designate priority conservation areas within the watershed project boundary. As with the system of Jones and Stokes (1990), physical parameters of vernal pool variability were not quantitatively described within or between landforms for the Cosumnes River Watershed Project.

5.2 Classification System of Vernal Pool Complexes for the SSHCP

The SSHCP Vernal pool classification system includes a modification of the landform approach of Jones and Stokes (1990). This landform classification was used to describe vernal pool conservation goals within the Sacramento County General Plan (1993). TNC also used a landform-based approach for conservation planning in the Cosumnes River Watershed Project in southeast Sacramento County (Reiner and Swenson 2000), although it was slightly modified from the approach first proposed by Jones and Stokes (1990).

This current SSHCP classification system builds on these approaches, with additional refinement afforded by currently available GIS technology and GIS geological formation data (California Geological Survey 2003), and recent SSHCP Land Cover Types produced by EDAW (2005).

The SSHCP classification system for vernal pools/wetlands is intended to be workable for the scale and resolution of the SSHCP mapping effort, and for the general timeline and budget constraints of the SSHCP. Within the scope of these considerations, the classification system is intended to be refined enough to identify, delineate and prioritize conservation needs for the region's vernal wetlands to the fullest extent possible at this time.

This vernal wetland classification system will increase the probability that overall biodiversity, special-status species, and myriad complex ecological functions operating up to the landscape level, are captured within appropriate and proportional mitigation-related habitat preserves.

Analysis of vernal wetland distribution in the SSHCP Study Area is based on the mapping conducted by the Geographical Information Center (GIC) in Chico, California in 2005 (Figure 4). Delineation of vernal wetlands was performed by use of ortho-rectified black and white aerial photographs that were flown on March 15, 2001. These orthophoto images were brought into ArcView 3.3 GIS software and the vernal wetland signatures were digitized into polygons which were recorded as a shape file. Vernal pool/wetlands were identified primarily by visual signatures, including contrasting shades (color) and to some degree texture and shape.

The mapping criteria and methodology used for the SSHCP Study Area were similar to those used by GIC in creating regional maps of vernal pool wetlands for Tehama County and Shasta County. In the SSHCP Study Area, these wetlands were usually found in isolation and sometimes are interspersed with and/or connected to swales. The vernal pools/wetlands usually

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have a relatively distinct boundary or contrasting edge that makes them visually discernible from less distinct saturated soil formations (“spongy areas”).

The vernal pool/wetland delineations conducted remotely by interpretation of aerial photos are expected to differ somewhat from jurisdictional vernal pool acreages obtained using the standard USCOE (1987) 3-parameter approach (boundaries determined on the ground using indicators of hydrology, hydric soil and hydrophytic vegetation).

This is an unavoidable consequence of remote delineation. Comparison of the remote delineation with on-the-ground 3-parameter delineations was made at a few sites where the jurisdictional delineations were available (vicinity of Sunrise-Douglas and Mather Field vernal pool complexes). In these cases, there was good correspondence in the polygons and signatures derived by these two methods (Radmacher pers. comm.; Sacramento County 2005). It is important to note though, that some of the other landscape settings may differ in agreement between the remotely mapped vernal wetlands and what is actually on the ground. It is critical to note that owing to time constraints and lack of access to private property, on-the-ground verification/delineation of vernal wetlands is not possible at this time.

Expected discrepancies between results of the two delineation scales and methods are likely to include:

1. ***Overestimation of the number and acreage of jurisdictional vernal pool wetland features using the aerial photo data set:*** On the aerial photograph, some features delineated as vernal wetlands may appear vernal pool- like, with defined boundaries and hydric reflective signatures that contrast with the surrounding upland annual grassland. In reality however, these wetland features may or may not support an actual vernal pool hydrologic cycle. If the mapped feature ponds water for too short duration, the feature may be a less-specialized seasonal wetland; if ponding is of excessive duration, the feature may actually be a less specialized seasonal marsh. In addition, some mapped signatures may not be associated with ponded basins at all; rather they may merely reflect saturated soil profiles without “pools”, especially with soils heavy in clay. In all three cases, wetland features mapped that do not support the vernal pool hydrologic cycle do not provide habitat support function for the vernal pool flora and fauna.
2. It is important to note that this type of error is not likely to apply equally across all vernal pool complexes that occur on the various geologic formations. For instance, the mapping of vernal pools is more likely to be very accurate and precise for the vernal pools associated with the high-terrace Laguna Formation. In contrast, accuracy and precision is comparatively less for vernal pools occurring on the heavier clay soils associated with the low terrace Riverbank Formations.

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3. ***Underestimation of the number of separate and/or small jurisdictional vernal wetland features using the aerial photo data set:*** In some cases, the higher degree of resolution afforded by use of three parameters on the ground will result in exclusion of small non-wetland areas that bridge closely-juxtaposed wetland basins. From the scale of the aerial photograph, the shallow bridges are not discernible, and so multiple jurisdictional-delineable basins are conjoined and a lesser number of larger pools are perceived. In addition, a number of isolated smaller/shallower wetlands that exhibit less distinct visual signatures were likely overlooked on the aerial photo delineation, and would be included in the 3-parameter field delineation.
4. ***Underestimation of size of functioning “hydrologic complex” with the 3-parameter delineation;*** in the preceding two cases, the differences between the two delineation methods trend towards increased resolution of jurisdictional boundaries using the 3-parameter field delineation. Importantly however, the 3-parameter approach can result in underestimation of the functional wetland area. Any given vernal wetland area is functionally related with surrounding vernal pools, seasonal wetland ecotones and with uplands, subterranean groundwater and surrounding saturated soil profiles. These areas are involved with the functions of hydrology, element cycling, and habitat support, but they may not satisfy one or more of the 3 field criteria, and so are usually excluded from jurisdictional acreage calculations.

Owing to the regional-scale view afforded, and greatly increased resolution and accuracy as compared to the previous regional vernal pool map (Jones and Stokes 1990), the map produced from the 1:200-scale aerial photograph (GIC 2005) is highly valuable for regional conservation planning and is used here for the SSHCP.

It is important to consider however, that the 3 considerations discussed above, combined with human error that is inherent in the aerial photo-mapping and digitizing process, somewhat limit the 1:200-scale GIS layer with regard to calculating exact vernal wetland acreages for precision impact analysis and mitigation planning. Owing to time and budget constraints and lack of access to private property however, on-the-ground delineations are not possible to conduct prior to completion of the SSHCP. Accurate three-parameter jurisdictional delineations will eventually be conducted on all lands as they are developed and on all preserves as they are established.

5.2.1 Classification by Geologic Formations

Physical parameters of vernal pool complexes appear to vary by geologic formation. These factors may include drainage area, slope, soil structure, soil depth, pool size, pool depth, timing of vernal pool hydrologic cycle and vernal pool interconnectivity. These physical parameters in turn affect the structure and ecological dynamics of the associated vernal pool flora and fauna.

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Different geologic formations support characteristic vernal pool types. In addition, specific geologic formations may possess specific biogeographic legacies that are reflected in present day patterns of vernal pool plant and animal biodiversity.

It follows then, that in order to ensure preservation of the full spectrum of impacted vernal pool types and functions, mitigation in-kind will involve preservation/restoration of vernal pools that occur in as close proximity as possible on the same type of geologic formation.

5.2.2 Classification of SSHCP Vernal Pool Complexes with Vernal Wetland-Acre/Density Index (VWADI)

In addition to correlation with geologic formations, a Vernal Wetland Acre/Density Index (VWADI) is used to describe and classify the vernal pool complexes within the SSHCP Study Area. This index is based on the variation in vernal wetland area (acres), and variation in vernal wetland density (number of vernal wetlands per unit land area). These two parameters, assessed together as an index for standardized 160-acre land analysis units, will serve as a primary descriptor of the range of spatial-ecological variability of vernal pool/wetland types in the SSHCP Study Area, within geological formations (see Section 6).

These analyses will provide the framework for the development of the SSHCP vernal pool-annual grassland habitat conservation strategy. For each parameter proposed however, full consideration of assumptions and limitations is required particularly as they relate to resolution and accuracy of the descriptive model (e.g., it is beneficial to know which ecological situations are likely to be overlooked, why, and what is the significance).

Additional ecological measures are also desirable for a more complete and accurate description of spatial and functional variability of vernal pools and vernal pool complexes (Jokerst 1993; Leidy and White 1998; Wacker and Kelly, 2004). It is imperative to consider vernal pool functions and processes at the landscape-scale as well to maximize the likelihood of achieving long-term conservation goals (Alexander and Schlising 1998; Jokerst 1993; Wacker and Kelly, 2004;). Ongoing vernal pool mitigation efforts have received criticism for focusing overly on replacement of acreage while giving little attention to the functioning landscape-scale ecosystem (Jokerst 1993; Wacker and Kelly 2004).

For the purposes of the SSHCP, a GIS-derived spatial-ecological index has been developed that allows for a more refined and quantifiable assessment of the region's vernal pool complexes. This relatively simple index is used here in conjunction with earlier regional conservation strategies that were based on association of vernal pool complexes with landform and geologic formation (Jones and Stokes 1990; Reiner and Swenson 2000). This VWADI is based on two parameters that are readily measurable remotely with GIS technology: 1) density of vernal

APPENDIX B-1 (Continued)

wetland features per 160-acre Land Analysis Unit(s) (LAU), and 2) wetted acres of vernal wetland habitat per 160-acre LAU.

Note that the size (area) of the vernal wetlands, a third important parameter, is inferable when vernal wetland density and wetted acres in each 160-acre LAU are plotted together on x and y axes. These three parameters considered together as an index reflect landscape-scale spatial relationships with ecological implications that are not discernible by considering each of the parameters in isolation (see following discussion).

Specifically, the VWADI is used here in the SSHCP to more accurately perform the following 3 tasks:

1. Describe spatial-ecological variability of vernal pool landscapes in the greater SSHCP Study Area;
2. Describe and quantify spatial-ecological variability of vernal pool landscapes within and between the various geologic formations encompassed by the SSHCP Study Area;
3. Describe and quantify spatial-ecological variability of vernal pool landscapes within and between different planning areas within the SSHCP Study Area (e.g., inside and outside of UDA).

It is critical to note that although the index itself is relatively simple, the exact utility is determined by the type and quality of the spatial data available. The GIS-data set utilized for the SSHCP was derived through manual delineation of black and white aerial photographs (scale: 1 inch = 400 feet) with limited subsequent field verification (see discussion under Section 5.2 above).

5.2.3 Development of the Vernal Wetland Acre/Density Index (VWADI)

The VWADI was produced by first creating a GIS grid-layer comprised of evenly distributed, contiguous 160-acre squares and then superimposing the grid-layer over the entire SSHCP Study Area on the GIS base Geologic Formation map. The 160-acre square grid unit was chosen for several reasons: this size and shape corresponds with $\frac{1}{4}$ of a 640-acre section and it therefore roughly corresponds with land-ownership boundaries; also, since preserves should be made as large in area as possible, use of multiple 160-acre subunits will allow for more detailed analysis and preserve planning. The grid units are hereafter referred to as LAUs.

A numbering system was then created to assign a unique identifier to each of the 2,311 LAUs. It was found that 1,372 LAUs encompass vernal pool habitat in the SSHCP Study Area as of 2006.

APPENDIX B-1 (Continued)

Once the grid system was created, the GIS program was queried to obtain the following two values for each of the 160-acre LAUs:

1. Vernal wetland density expressed as the total number of vernal wetland features encompassed within the LAU, including pools shared with contiguous LAUs; and
2. Total wet acres of vernal wetland habitat, including the portion(s) of shared wetland(s) that occur within the given LAU;

The density and wet-acre values were then ordinated onto standard-scale X and Y-axes, respectively (see Figures 10, 12, 14, and 16). This ordination results in visual-spatial segregation of different types of vernal pool complexes within continua of density and wetted acreage. Note that within any given LAU and relative to another, a doubling of wetted acreage with constant vernal pool density corresponds to a doubling in the average vernal pool/wetland size (area). Thus, even though it is not a directly measured parameter, vernal pool size is inferable within the index.

Once this ordination was performed for LAUs nested within each of the geologic formations and landforms, and within each of the planning areas previously described (see tasks 1-3, Section 5.2.2), the resulting X-Y Cartesian Grid was divided into 25 VWADI categories by designating 5 intervals along the X-axis (based on vernal pool density and designated A-E), and 5 intervals along the Y-axis (based on vernal pool wet-acres and designated 1-5; (see Figures 11, 13, 15, and 17). In this fashion, each 160-acre LAU is identifiable according to one of these 25 standardized alphanumeric values.

After creation of the 25 VWADI values and ordination of the LAUs a summary calculation was made that describes the numerical and spatial distribution of each “VWADI Category Type” that exists within the SSHCP Study Area for each geologic landform. For example and as indicated in Figure 11, on the Laguna Geologic Formation there are 15 160-acre LAUs that correspond to the D4 VWADI Category; 12 of the LAUs are located inside the UDA and three are outside of the UDA; there are a total of 122 wetted acres present in this category, of which 99 acres are located inside and 23 acres are outside of the UDA.

As with any other ecological index, there are assumptions and limitations to the model that require consideration. The following is an account of rationale, assumptions and limitations as they pertain to use of the VWADI for the purpose of the SSHCP.

Assumptions Regarding the Mapping Data:

- The GIS layer base map (GIC 2005) used to produce the index reasonably reflects conditions in the field with regard to vernal wetland locations and boundaries (see Section 5.0 above).

APPENDIX B-1 (Continued)

- Inaccuracies in delineation of vernal wetland boundaries on the GIS layer base map differ between Geologic Formations (e.g., accuracy is higher for vernal pools associated with high-terrace Laguna Formation, and is lower on clay soils of low-terrace Riverbank Formation).

Assumptions Regarding Vernal Pool/Geologic Formation Relations:

- Determinant relationships between geologic formations and physical characteristics of associated vernal pools, and in turn, physical characteristics of vernal pools influence vernal pool biota. For this reason, acquisition of land or easements will occur over broad range of formations.

Assumptions Regarding Vernal Wetland Density and Ecological Interconnectivity:

- Ecological interconnectivity increases with increasing vernal pool density per given land unit. For example two vernal pools located within 3 meters of each other inter-relate differently ecologically than two pools located 90 meters apart.
- Interconnectivity at the local scale generally increases with an increase in the size of any given vernal pool preserve supporting vernal pool complexes of a given density. Similarly, at the regional scale, interconnectivity increases with an increase in the number of juxtaposed large vernal pool preserves supporting vernal pool complexes.
- Maximum interconnectivity is associated with the largest areas encompassing the densest of pool complexes.
- High-density complexes possess specific ecological properties (e.g., attractiveness to migratory waterfowl, greater function of meta-population dynamics, increased number of ecological niches, and population stability in light of drought-wet cycles and perhaps even climate change).
- Vernal wetlands and complexes occur along gradients of interconnectivity (hydrological-spatial).

Assumptions Regarding Size (area) of Vernal Wetlands:

- Larger vernal pools (by area) possess specific ecological properties, functions and values that are different from smaller pools (e.g., a greater volume of water for a given depth, a larger number of possible habitat niches, increased attractiveness to migratory waterfowl).
- Vernal wetlands occur along gradients of size (area-depth).
- Size (area) may be a useful indicator of duration of hydro-period.
- Larger pools (by area) are more infrequently occurring.

APPENDIX B-1 (Continued)

Assumptions Regarding Vernal Pool Hydrology:

- Vernal pool hydro-period is one of the primary determinants in structuring the general vernal pool biological assemblage.
- Size (area) may be a useful indicator of hydrology.
- Vernal wetlands occur along gradients of severity of seasonal inundation cycle (duration/depth).
- Vernal pools exhibiting “deep-pool” hydrology (long duration) are more infrequently occurring.

Assumptions Regarding Vernal Pool Conservation Values:

- Vernal wetlands, regardless of size or interconnectivity, possess intrinsic ecological functions and values.
- High-density vernal pool complexes are infrequently occurring, are likely to be more ecologically complex and therefore possess higher conservation value.
- Large vernal pools are more infrequently occurring (in isolation and in complexes), they tend to be more ecologically complex than small vernal pools (in isolation and in complexes) and therefore possess higher conservation value.
- Vernal pools that are known to support special-status plant and/or animal species have high conservation value regardless of interconnectivity or size.

The VWADI approach will serve as an initial guide to address the spatial distribution of differing types of vernal pool complexes, and to aid in formulation of vernal pool habitat conservation goals (see Section 6.0). As time passes and more 3-parameter jurisdictional delineations are conducted in the SSHCP Study Area, the accuracy and precision of the VWADI approach will improve.

5.3 Results of VWADI Analysis

5.1 High Terrace Landform

The High Terrace Landform includes the Laguna, Turlock Lake and Ione Geologic Formations. The relationship between vernal wetland acres and vernal wetland density for the three geologic formations are illustrated in Figure 10 and numerically summarized in Figure 11.

5.1.1 *Laguna Geologic Formation (TI)*

The Laguna Geologic Formation encompasses a total of 403 LAU (29.4%), of which 162 (40.2%) are located inside of the UDA and 241 (59.8%) are located outside of the UDA. The 403 LAU are distributed among the five VWADI categories as follows: 104 LAU are included in

APPENDIX B-1 (Continued)

Category 1 (36 LAU are inside the UDA and 68 are outside the UDA), 85 LAU are included in Category 2 (38 LAU are inside the UDA and 47 are outside the UDA), 90 LAU are included in Category 3 (36 LAU are inside the UDA and 54 are outside the UDA), 64 LAU are included in Category 4 (21 LAU are inside the UDA and 43 are outside the UDA) and 60 LAU are included in Category 5 (19 LAU are inside the UDA and 41 are outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 557 and the total wetland acres per 160-acre LAU range from 0.006 to 20.12 acres.

5.1.2 *Turlock Lake Geologic Formation (Tpl)*

The Turlock Lake Geologic Formation encompasses a total of 11 LAU (0.8%), of which 11 (100%) are located inside of the UDA. The 11 LAU are distributed among the five VWADI categories as follows: one LAU is included in Category 1, two LAU are included in Category 2, four LAU are included in Category 3, and four LAU are included in Category 4. There are no LAU included within Category 5.

The number of vernal wetlands per 160-acre LAU was found to range from 11 to 84 and the total wetland acres per 160-acre LAU range from 0.3 to 6.4 acres.

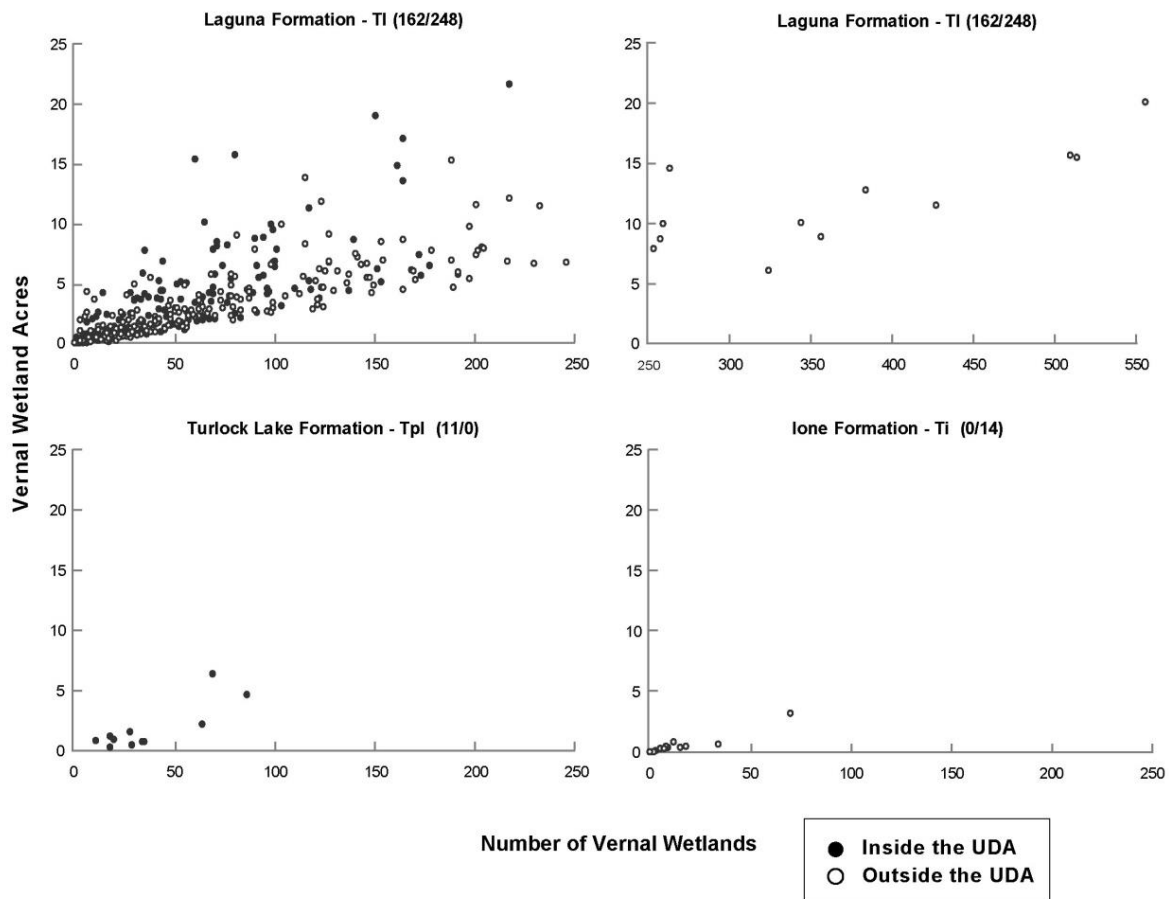
5.1.3 *Ione Geologic Formation (Ti)*

The Ione Formation encompasses a total of 13 LAU (0.9%), of which 13 (100%) are located outside of the UDA. The 13 LAU are distributed among the five VWADI categories as follows: one LAU is included in Category 2, one LAU is included in Category 3, three LAU are included in Category 4 and eight LAU are included in Category 5. There are no LAU included within Category 1.

The number of vernal wetlands per 160-acre LAU range from 1 to 71 and the total wetland acres per 160-acre LAU range from 0.02 to 3.15 acres.

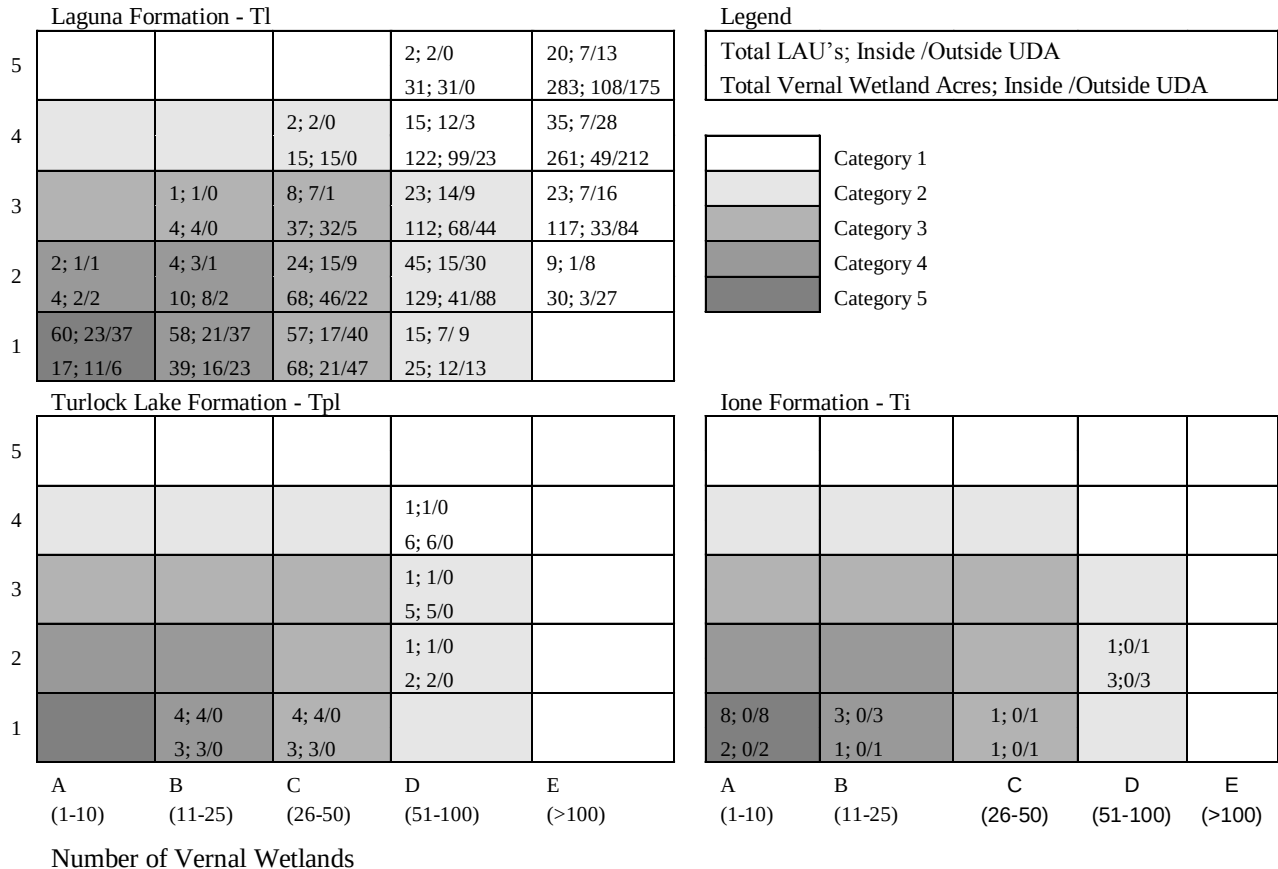
APPENDIX B-1 (Continued)

Figure 10 Relationship of number of vernal wetlands to wetted acres on High Terrace Landform geologic formations. Each symbol represents one LAU. Black symbols represent LAUs inside the Urban Development Area, while white symbols represent LAUs outside the Urban Development Area. Numbers shown below geologic formation names are number of LAUs inside and outside the Urban Development Area (# Inside / # Outside). Abbreviations are: LAU= Land Analysis Unit.



APPENDIX B-1 (Continued)

Figure 11 Vernal Wetland Acre/Density Index (VWADI) for High Terrace Landform geologic formations. Number of vernal wetlands (A-E) and vernal wetland acres (1-5) are shown categorically on the x and y axes, respectively. Abbreviations are: LAU = Land Analysis Unit and UDA = Urban Development Area.



APPENDIX B-1 (Continued)

5.2 Low Terrace Landform

The Low Terrace Landform includes the Undivided Riverbank, Upper Unit Riverbank, Middle Unit Riverbank, Lower Unit Riverbank and South Fork Gravels Geologic Formations. The relationship between vernal wetland acres and vernal wetland density for the five geologic formations are illustrated in Figure 12 and numerically summarized in Figure 13.

5.2.1 *Undivided Riverbank Geologic Formation (Qr)*

The Undivided Riverbank Formation encompasses a total of 261 LAU (17.9%), of which 68 (26.1%) are located inside of the UDA and 193 (73.9%) are located outside of the UDA. The total of 261 LAU are distributed among the five VWADI categories as follows: 41 LAU are included in Category 1 (seven LAU are inside the UDA and 34 are outside the UDA), 26 LAU are included in Category 2 (three LAU are inside the UDA and 23 are outside the UDA), 35 LAU are included in Category 3 (five LAU are inside the UDA and 30 are outside the UDA), 50 LAU are included in Category 4 (nine LAU are inside the UDA and 41 are outside the UDA) and 109 LAU are included in Category 5 (44 LAU are inside the UDA and 65 are outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 254 and the total wetland acres per 160-acre LAU range from 0.01 to 58.02 acres.

5.2.2 *Upper Unit Riverbank Geologic Formation (Qru)*

The Upper Unit Riverbank Formation encompasses a total of 105 LAU (7.2%), of which 27 (25.7%) are located inside of the UDA and 78 (74.3%) are located outside of the UDA. The 105 LAU are distributed among the five VWADI categories as follows: 15 LAU are included in Category 1 (all outside the UDA), six LAU are included in Category 2 (one LAU is inside the UDA and five are outside the UDA), seven LAU are included in Category 3 (one LAU is inside the UDA and six are outside the UDA), 15 LAU included in Category 4 (four LAU are inside the UDA and 11 are outside the UDA) and 62 LAU are included in Category 5 (21 LAU are inside the UDA and 41 are outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 237 and the total wetland acres per 160-acre LAU range from 0.01 to 26.98 acres.

5.2.3 *Middle Unit Riverbank Geologic Formation (Qrm)*

The Middle Unit Riverbank Formation encompasses a total of 63 LAU (4.6%), of which 15 (23.8%) are located inside of the UDA and 48 (76.2%) are located outside of the UDA. The 63 LAU are distributed among the five VWADI categories as follows: five LAU are included in Category 1 outside the UDA, eight LAU are included in Category 2 (one LAU is inside the UDA

APPENDIX B-1 (Continued)

and seven are outside the UDA), eight LAU are included in Category 3 (one LAU is inside the UDA and seven are outside the UDA), 12 LAU are included in Category 4 (two LAU are inside the UDA and ten are outside the UDA) and 30 LAU are included in Category 5 (11 LAU are inside the UDA and 19 are outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 114 and the total wetland acres per 160-acre LAU range from 0.005 to 17.98 acres.

5.2.4 Lower Unit Riverbank Geologic Formation (Qrl)

The Lower Unit Riverbank Formation encompasses a total of 108 LAU (7.9%), of which 79 (73.1%) are located inside of the UDA and 29 (26.9%) are located outside of the UDA. The 108 LAU are distributed among the five VWADI categories as follows: 20 LAU are included in Category 1 (six LAU are inside the UDA and 14 are outside the UDA), nine LAU are included in Category 2 (six LAU are inside the UDA and three are outside the UDA), five LAU are included in Category 3 (all LAU are inside the UDA), 14 LAU are included in Category 4 (13 LAU are inside the UDA and one is outside the UDA) and 60 LAU are included in Category 5 (49 LAU are inside the UDA and 11 are outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 90 and the total wetland acres per 160-acre LAU range from 0.001 to 47.92 acres.

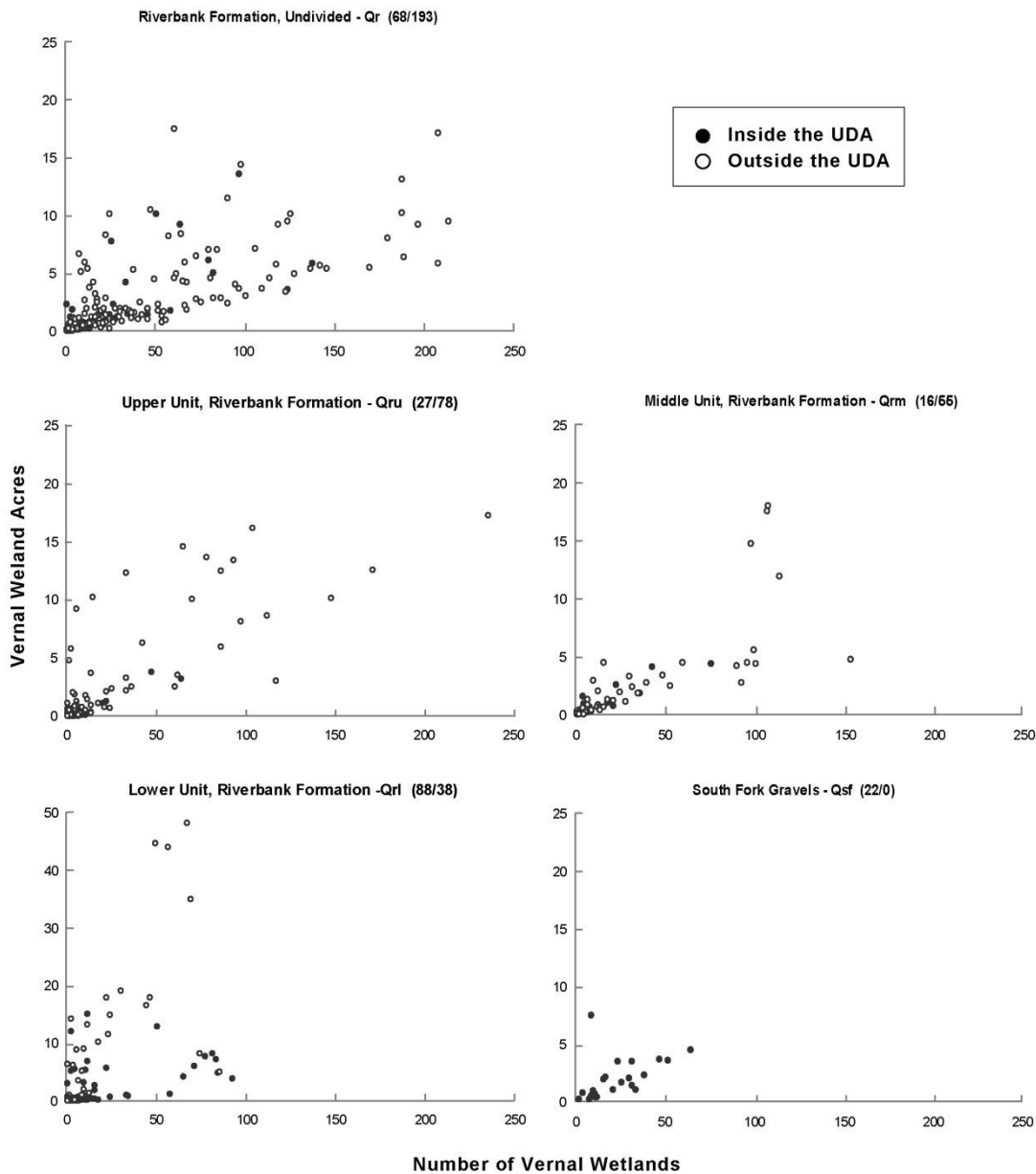
5.2.5 South Forks Gravel Geologic Formation (Qsf)

The South Forks Gravel Formation encompasses a total of 23 LAU (1.7%), of which 23 (100%) are located inside of the UDA. The 23 LAU are distributed among the five VWADI categories as follows: three LAU are included in Category 2, seven LAU are included in Category 3, six LAU are included in Category 4 and seven LAU are included in Category 5. There are no LAU included within Category 1.

The number of vernal wetlands per 160-acre LAU range from 2 to 64 and the total wetland acres per 160-acre LAU range from 0.07 to 7.07 acres.

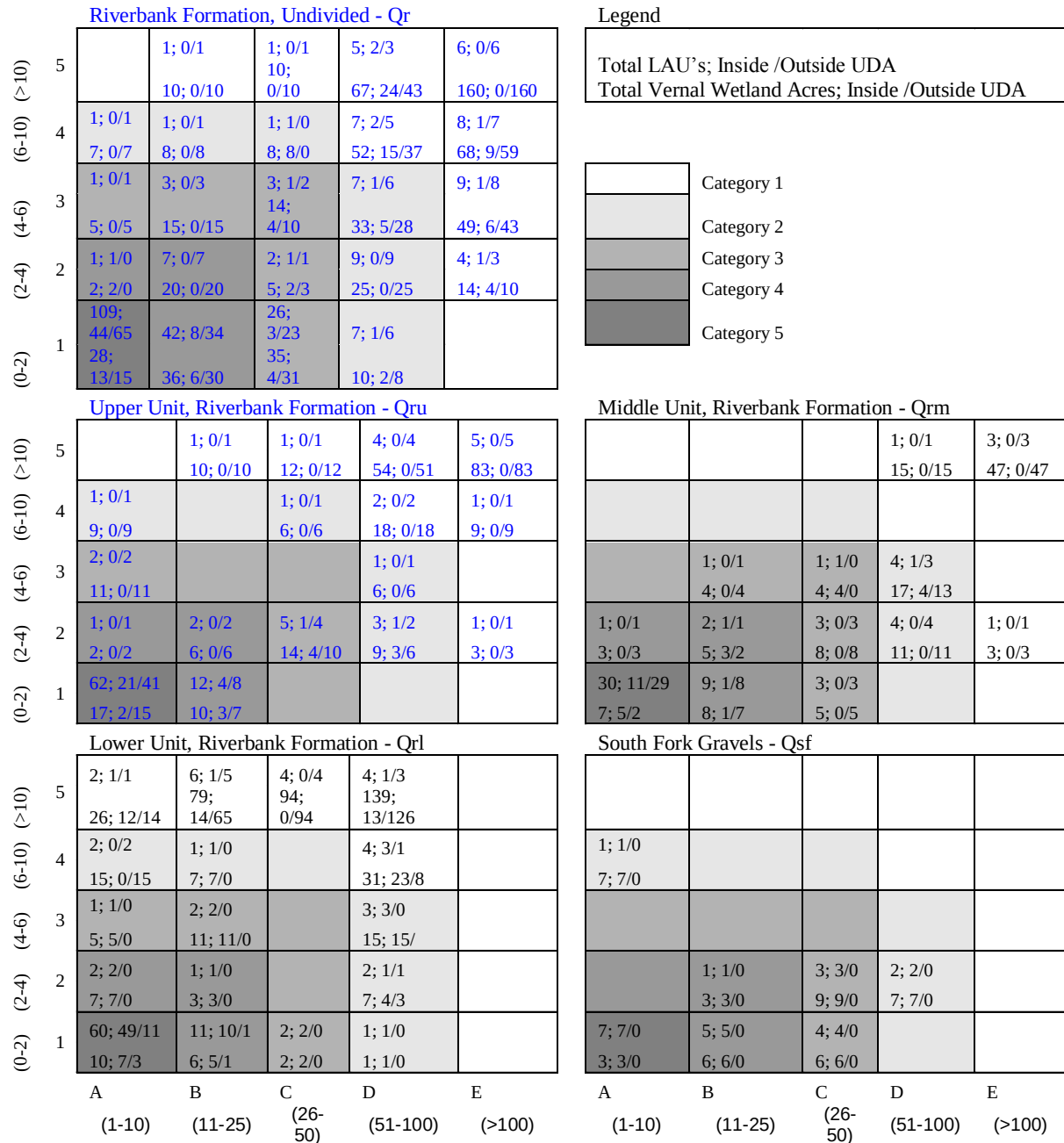
APPENDIX B-1 (Continued)

Figure 12 Relationship of number of vernal wetlands to wetted acres on Low Terrace Landform geologic formations. Each symbol represents one LAU. Black symbols represent LAUs inside the Urban Development Area, while white symbols represent LAUs outside the Urban Development Area. Numbers shown below geologic formation name are number of LAUs inside and outside the Urban Development Area (# Inside / # Outside). Abbreviations are: LAU= Land Analysis Unit.



APPENDIX B-1 (Continued)

Figure 13 Vernal Wetland Acre/Density Index (VWADI) for Low Terrace Landform geologic formations. Number of vernal wetlands (A-E) and vernal wetland acres (1-5) are shown categorically on the x and y axes, respectively. Abbreviations are: LAU = Land Analysis Unit and UDA = Urban Development Area



APPENDIX B-1 (Continued)

5.3 Volcanic Mudflow Landform

The Volcanic Mudflow Landform includes the Mehrten and Valley Springs Geologic Formations. The relationship between vernal wetland acres and vernal wetland density for the two geologic formations are illustrated in Figure 14 and numerically summarized in Figure 15.

5.3.1 *Mehrten Geologic Formation (Tm)*

The Mehrten Formation encompasses a total of 164 LAU (12%), of which 25 (15.2%) are located inside of the UDA and 139 (84.8%) are located outside of the UDA. The 164 LAUs are distributed among the five VWADI categories as follows: 47 LAUs are included in Category 1 (all 47 are outside the UDA), 31 LAUs are included in Category 2 (three LAUs are inside the UDA and 28 are outside the UDA), 27 LAUs are included in Category 3 (six LAU are inside the UDA and 21 are outside the UDA), 30 LAUs are included in Category 4 (eight LAUs are inside the UDA and 22 are outside the UDA) and 29 LAUs are included in Category 5 (eight LAUs are inside the UDA and 21 are outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 358 and the total wetland acres per 160-acre LAU range from 0.007 to 12.54 acres.

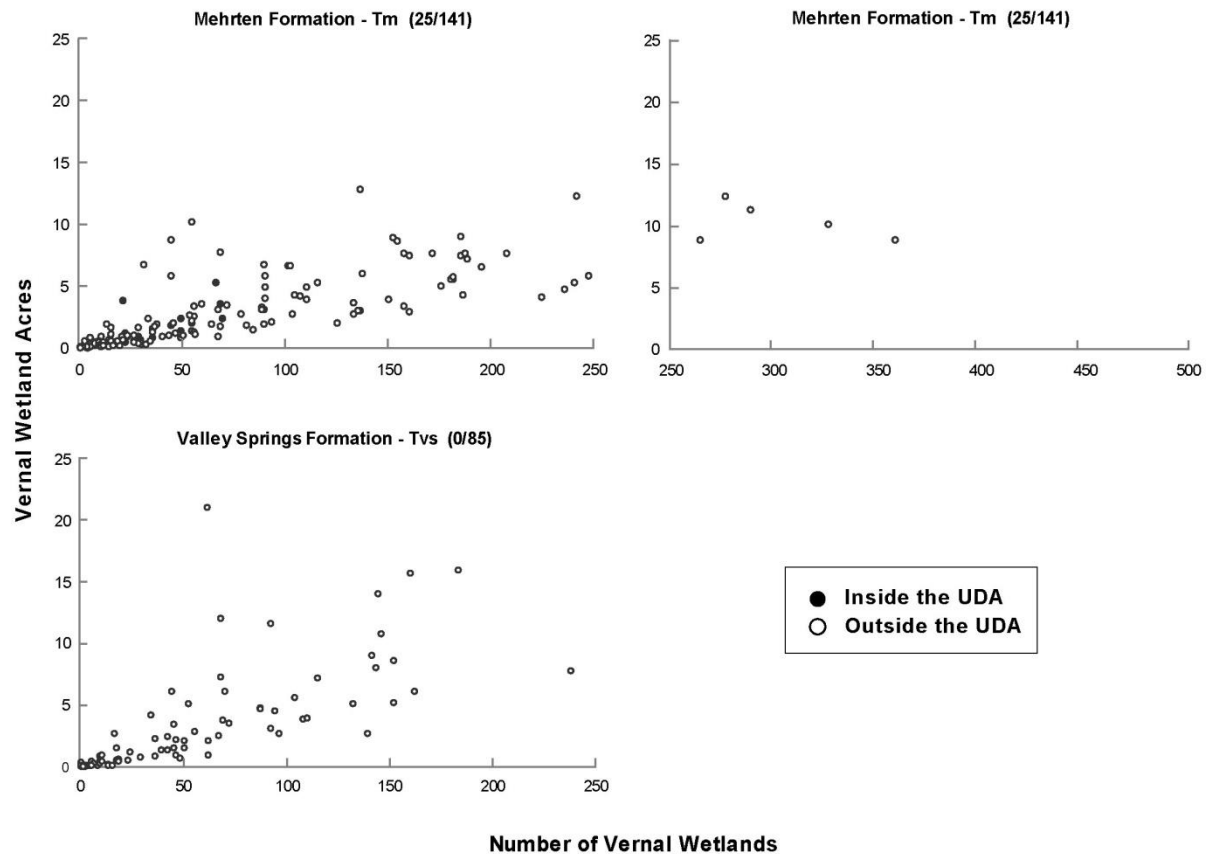
5.3.2 *Valley Springs Formation (Tvs)*

The Valley Springs Formation encompasses a total of 85 LAUs (6.2%), of which 85 (100%) are located outside of the UDA. The 85 LAUs are distributed among the five VWADI categories as follow): 21 LAUs are included in Category 1, 14 LAU are included in Category 2, 13 LAU are included in Category 3, 11 LAUs are included in Category 4 and 26 LAUs are included in Category 5.

The number of vernal wetlands per 160-acre LAU was found to range from 1 to 239 and the total wetland acres per 160-acre LAU range from 0.004 to 21 acres.

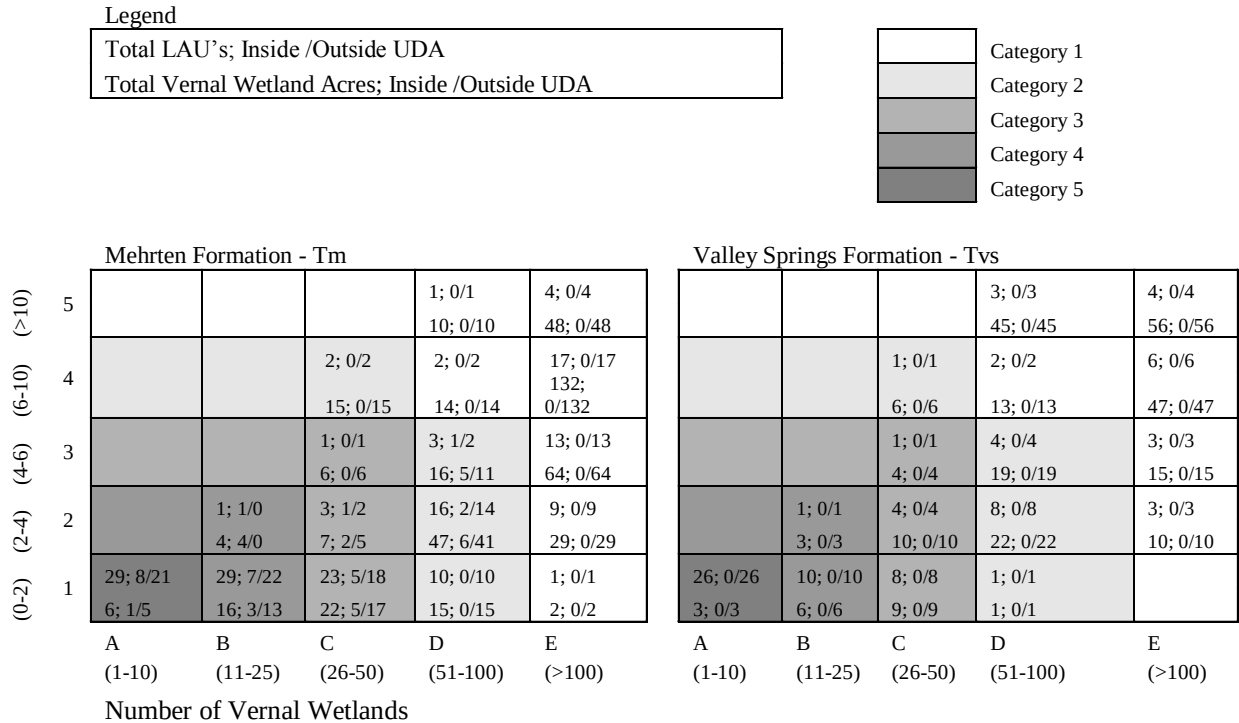
APPENDIX B-1 (Continued)

Figure 14 Relationship of number of vernal wetlands to wetted acres on Volcanic Mudflow Landform geologic formations. Each symbol represents one LAU. Black symbols represent LAUs inside the Urban Development Area, while white symbols represent LAUs outside the Urban Development Area. Numbers shown below geologic formation name are number of LAUs inside and outside the Urban Development Area (# Inside / # Outside). Abbreviations are: LAU= Land Analysis Unit.



APPENDIX B-1 (Continued)

Figure 15 Vernal Wetland Acre/Density Index (VWADI) for Volcanic Mudflow Landform geologic formations. Number of vernal wetlands (A-E) and vernal wetland acres (1-5) are shown categorically on the x and y axes, respectively. Abbreviations are: LAU = Land Analysis Unit and UDA = Urban Development Area.



APPENDIX B-1 (Continued)

5.4 Other

The other Geologic Formations which do not fall in High Terrace, Low Terrace or Volcanic Mudflow Landform includes the Upper Unit Modesto, Undifferentiated Surficial Alluvial Deposits, Dredge Tailing and Artificial Fill and Metamorphic Rocks, Undifferentiated Geologic Formations. The relationship between vernal wetland acres and vernal wetland density for these 4 geologic formations are illustrated in Figure 16 and numerically summarized in Figure 17. In addition to these four geologic formations, three other formations are included within this description (North Merced Gravels, Alluvial Deposits and Alluvial Floodplain Deposits), but are not included in the tables or graphs due to low overall number and acreage of vernal wetlands per LAU.

5.4.1 *Upper Unit Modesto Geologic Formation (Qmu)*

The Upper Unit Modesto Formation encompasses a total of 46 LAUs (3.4%), of which 46 (100%) are located outside of the UDA. The 46 LAUs are distributed among the five VWADI categories as follows: five LAUs are included in Category 1, one LAU is included in Category 2, one LAU is included in Category 3, six LAUs are included in Category 4 and 33 LAUs are included in Category 5.

The number of vernal wetlands per 160-acre LAU was found to range from 1 to 146 and the total wetland acres per 160-acre LAU range from 0.008 to 15.36 acres.

5.4.2 *Undifferentiated Surficial Alluvial Deposits Geologic Formation (Qu)*

The Undifferentiated Surficial Alluvial Deposits Formation encompasses a total of five LAU (0.4%), of which one (20%) is located inside of the UDA and four (80%) are located outside of the UDA. The 5 LAU are distributed among the five VWADI categories as follows: one LAU is included in Category 2 inside the UDA, one LAU is included in Category 3 outside the UDA and three LAUs are included in Category 5 outside of the UDA. There are no LAUs in Category 1 or 4.

The number of vernal wetlands per 160-acre LAU was found to range from 1 to 98 and the total wetland acres per 160-acre LAU range from 0.03 to 5.45 acres.

5.4.3 *Dredge Tailing and Artificial Fill Geologic Formation (t)*

The Dredge Tailing and Artificial Fill Formation encompasses a total of 23 LAU (1.7%), of which 14 (60.9%) are located inside of the UDA and 9 (39.1%) are located outside of the UDA. The 23 LAU are distributed among the five VWADI categories as follows: one LAU is included in Category 2 outside the UDA, two LAUs are included in Category 3 outside the UDA, five

APPENDIX B-1 (Continued)

LAUs are included in Category 4 LAUs are inside the UDA and one is outside the UDA) and 15 LAUs are included in Category 5 (10 LAUs are inside the UDA and five are outside the UDA).

The number of vernal wetlands per 160-acre LAU was found to range from 1 to 66 and the total wetland acres per 160-acre LAU range from 0.01 to 1.19 acres.

5.4.4 *Metamorphic Rocks, Undifferentiated Geologic Formation (pKu)*

The Metamorphic Rocks, Undifferentiated Geologic Formation encompasses a total of 84 LAU (6.1%), of which 1 (1.2%) is located inside of the UDA and 83 (98.8%) are located outside of the UDA. The 84 LAUs are distributed among the five VWADI categories as follows: five LAU are included in Category 2 outside the UDA), six LAUs are included in Category 3 outside the UDA, 15 LAUs are included in Category 4 (one LAU is inside the UDA and 16 are outside the UDA) and 58 LAUs are included in Category 5 outside the UDA).

The number of vernal wetlands per 160-acre LAU range from 1 to 88 and the total wetland acres per 160-acre LAU range from 0.005 to 6.80 acres.

5.5.5 *Alluvial Deposits, Undivided Geologic Formation (Qha)*

The Alluvial Deposits, Undivided Formation encompasses a total of one LAU (0.07%) which is located outside of the UDA. This LAU is included in Category 5. There are no LAU within Category 1, 2, 3 or 4.

The number of vernal wetlands per 160-acre LAU is one and the total wetland acres 0.40 acres.

5.5.6 *Alluvial Floodplain Deposits Geologic Formation (Qfp)*

The Alluvial Floodplain Deposits Geologic Formation encompasses a total of 10 LAU (0.7%), all of which are located outside of the UDA. Of these 10 LAUs, one LAU is included in Category 3 and nine LAUs are included in Category 5. There are no LAUs within Category 1, 2 or 4.

The number of vernal wetlands per 160-acre LAU range from 1 to 34 and the total wetland acres per 160-acre LAU range from 0.03to 1.85 acres.

5.5.7 *North Merced Gravels Geologic Formation (Qtnm)*

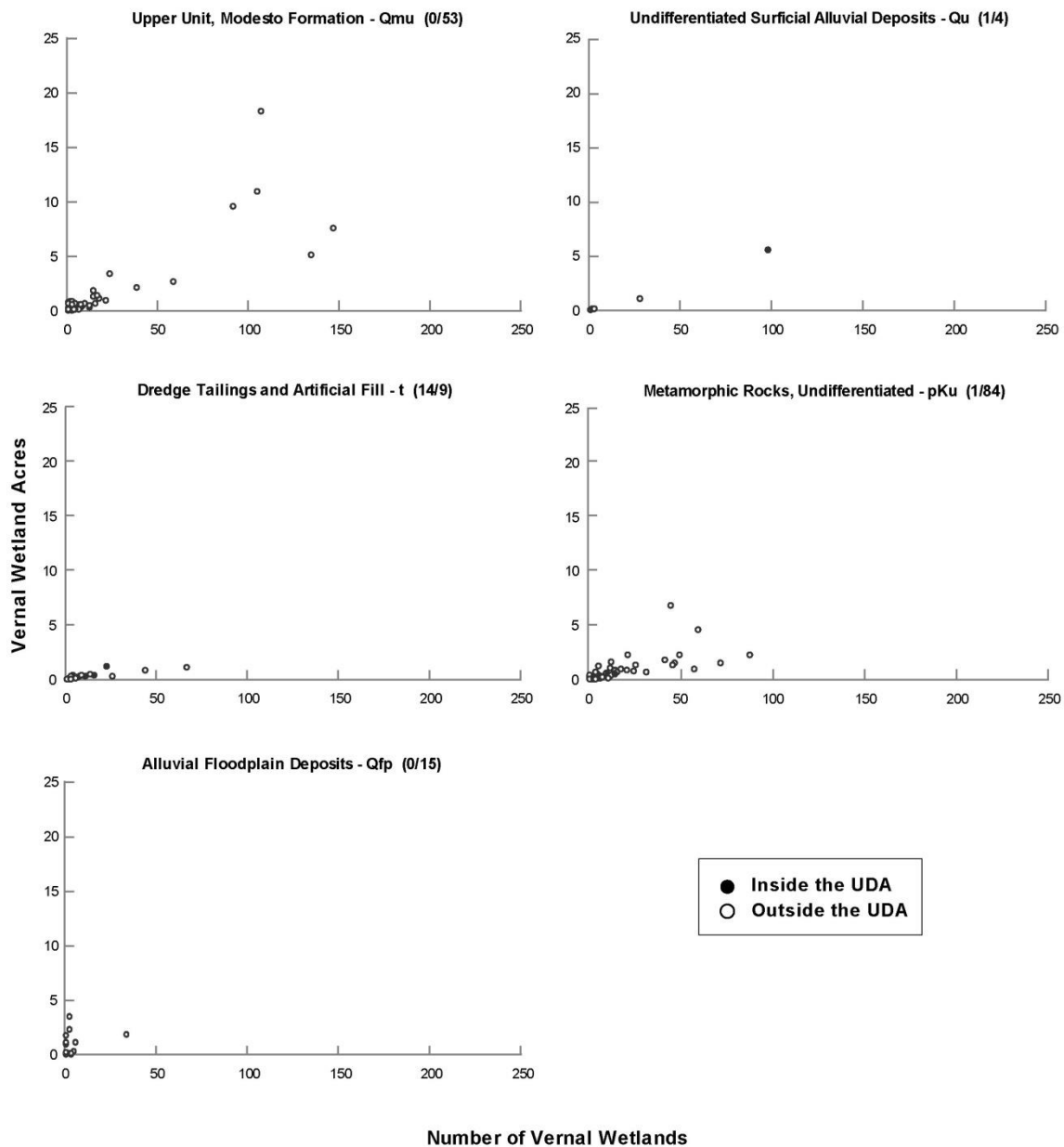
The North Merced Gravel Geologic Formation encompasses a total of two LAU (0.1%), both of which are located inside the UDA. One of the LAUs is included in Category 4 and one LAU is included in Category 5. There are no LAUs within Category 1, 2 or 3.

APPENDIX B-1 (Continued)

The number of vernal wetlands per 160-acre LAU range from 4 to 13 and the total wetland acres per 160-acre LAU range from 0.11 to 1.36 acres.

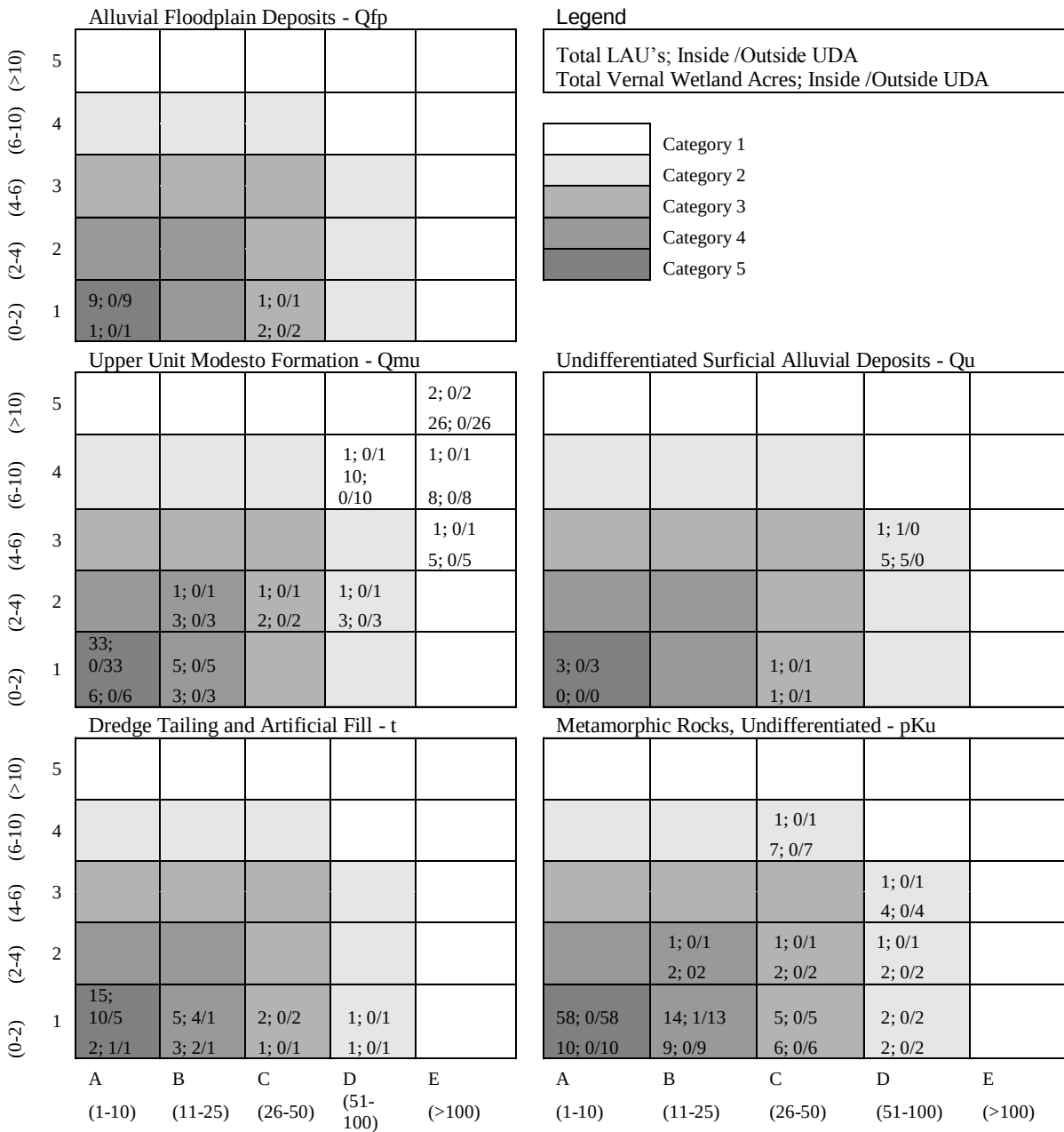
APPENDIX B-1 (Continued)

Figure 16 Relationship of number of vernal wetlands to wetted acres on other geologic formations (Qmu, Qu, t, and pKu). Each symbol represents one LAU. Black symbols represent LAUs inside the Urban Development Area, while white symbols represent LAUs outside the Urban Development Area. Numbers shown below geologic formation name are number of LAUs inside and outside the Urban Development Area (# Inside / # Outside). Abbreviations are: LAU= Land Analysis Unit.



APPENDIX B-1 (Continued)

Figure 17 Vernal Wetland Acre/Density Index (VWADI) for Other Geologic Formations (Qfp, Qmu, Qu, t, and pKu). Number of vernal wetlands (A-E) and vernal wetland acres (1-5) are shown categorically on the x and y axes, respectively. Abbreviations are: LAU = Land Analysis Unit and UDA = Urban Development Area.



6 VERNAL WETTED ACRE DENSITY INDEX (VWADI) AND PRESERVE DESIGN

The VWADI was used to classify and describe the spatial distribution of vernal pools and vernal pool complexes within the Study Area. This information was also used to develop the SSHCP vernal pool/ grassland habitat conservation strategy by assisting in identification and definition of proposed preserve zones. This index helps in the assignment of conservation value to each 160-acre LAU, based on a set of considerations and assumptions:

- LAUs with dense vernal pool complexes are infrequently occurring;
- LAUs with large vernal pools are infrequently occurring;
- LAUs with dense vernal pool complexes are ecologically unique and important because they provide vernal pool heterogeneity;
- LAUs with large vernal pools are ecologically unique and important;
- LAUs with large vernal pools and/or dense vernal pool complexes are valuable for conservation because of their infrequency and their ecological uniqueness.
- LAUs with large vernal pools and/or dense vernal pool complexes are valuable for conservation because their mitigation-preservation ratio allows for acquisition of the greatest wetted-acres with the minimal loss of developable upland areas.

Although high density complexes and large vernal pools are emphasized, it is important to note that “small” vernal pool types provide important habitat functions as well. It is assumed however, that the “small” or “shallow”-type vernal pool habitat is present as a sub-habitat type that is present in most vernal pool complexes.

Based on these considerations, it was decided that 5 quantitative categories of conservation value would be used to address the 25 VWADI categories; the highest conservation value will be placed on category 1 LAUs (most wetted acres with densest vernal pool complexes and largest number of large pools), and the least conservation value on category 5 LAUs (least wetted acres, and most isolated and smaller vernal pools). It is recognized that these categories, along with the VWADI values are somewhat subjective and may lack fine ecological resolution (e.g., are all A5/Category-1 and A4/Category-2 LAUs actually ecologically different?). This is, however an objective and quantifiable approach to describing landscape vernal pool patterns available at the present time.

The VWADI is designed to identify high-density vernal pool complexes. High-density pool complexes are targeted specifically because it maximizes (1) the amount of wetted acreages

APPENDIX B-1 (Continued)

within a given land Unit, (2) the number of vernal pools within a given land unit and (3) the connectivity between vernal pools within and between land units.

Protecting the maximum number of vernal pools is an essential part of this strategy specifically because (1) vernal pools provides the habitat (both occupied and suitable) for the 13 covered vernal pool species that need to be protected (2) it protects vernal pool heterogeneity including size, shape, depth, landform association and species diversity.

In order to preserve the most ecologically complex vernal pool habitats and to acquire the required wetland acres necessary to mitigate for the proposed impacts, Category 1 and 2 LAUs will be the primary targets for proposed preserves zones. Since all vernal pools, regardless of size or density possess ecological function and conservation values; the remaining LAUs will be targeted where available in order to provide connectivity, buffers and specific species conservation opportunities.

Land Analysis Units in Categories 1 and 2 of the VWADI system have particularly high value for the conservation of ecologically functional vernal pool complexes. It is necessary to conserve most of the acres in these categories both inside and outside the UDA. In particular, ecological connectivity increases with increasing vernal pool density per given land unit, maximum interconnectivity is associated with the largest areas encompassing the densest of pool complexes.

Category 3 and 4 LAUs are targeted in cases where they provide corridors and buffers to existing and proposed preserves, as well as opportunities to protect known locations of vernal pool covered species, unique large pools and pools on specific formations.

Category 5 LAUs will be targeted when they have a clearly defined conservation value such as “no take species”, or unique habitat features and qualities. These features may include large and/or deep vernal pools, corridors, high quality upland habitats, and suitable vernal pool creation/restoration mitigation sites.

The total number and percentages of the different VWADI categories for the 1,372 LAU with vernal wetlands is included below as well as the total vernal pool/wetland acres;

Category 1 (18.7% of all LAUs with vernal pool habitat; includes all LAUs with an VWADI value of A5, B5, C5, D5, E5, E4, E3, E2, E1 and D4). This category contains 2,480 wetland acres (62.2% of the total vernal pools/wetlands mapped within the SSHCP Study Area);

Category 2 (14.0% of all LAUs with vernal pool habitat; includes all LAUs with an VWADI of A4, B4, C4, D1, D2 and D3). This category contains 706 wetland acres (17.7% of the total vernal pools/wetlands mapped within the SSHCP Study Area);

APPENDIX B-1 (Continued)

Category 3 (14.7% of all LAUs with vernal pool habitat; includes all LAUs with an VWADI of A3, B3, C1, C2 and C3). This category contains 421 wetland acres (10.6% of the total vernal pools/wetlands mapped within the SSHCP Study Area);

Category 4 (16.8% of all LAUs with vernal pool habitat; includes all LAUs with an VWADI of A2, B1 and B2). This category contains 254 wetland acres (6.4% of the total vernal pools/wetlands mapped within the SSHCP Study Area);

Category 5 (35.8% of all LAUs with vernal pool habitat; includes all A1). This category contains 128 wetland acres (3.2% of the total vernal pools/wetlands mapped within the SSHCP Study Area).

APPENDIX B-1 (Continued)

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APPENDIX B-1 (Continued)

7 LITERATURE CITED

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APPENDIX B-2

Addendum to Vernal Pool Classifications

APPENDIX B-2

Addendum to Vernal Pool Classifications

1 PURPOSE

The purpose of this document is to explain the changes in the analysis methods described in *Vernal Pool Classifications* (Appendix B-1 of the Aquatic Resources Plan (ARP)) that were used to generate the results presented in the ARP. Specifically, the focus of this addendum is regarding the classification of SSHCP vernal pools and the Vernal Wetland Acre/Density Index (VWADI) (Section 5.2 of *Vernal Pool Classifications*).

2 MODIFICATIONS

There are three factors that were modified in the analysis presented in the ARP from those used in the 2010 *Vernal Pool Classifications* document that affect the results: (1) land cover data; (2) land analysis unit (LAU) size; and (3) assigned intervals for vernal pool wetted acreage categories. Each of these modifications is described below.

2.1 Land Cover Data

The 2010 *Vernal Pool Classifications* did not use the most current available land cover data, which identifies the size and location of the vernal pools. The original mapping efforts have been updated and refined at various times to reflect modifications of land cover types (such as cover type conversion), to accommodate an expansion of the Plan Area boundary, and to correct errors in the original mapping. The current land cover map provides fairly detailed information for the existing conditions in the Plan Area based on 2009 aerial photos and limited field-truthing, with the updates occurring in May 2010 and July 2012. The analysis presented in the ARP is based upon the current land cover data.

2.2 Land Analysis Units

The VWADI is based on the variation in vernal pool areas (acres) and variation in vernal pool density (number of vernal pools per unit land area). In the 2010 *Vernal Pool Classifications*, these two parameters were assessed together as an index for vernal pool resources within standardized 160-acre LAUs (i.e., one-quarter sections) and served as the primary descriptors of the range of spatial-ecological variability of vernal pools in the Plan Area. Based on an informal recommendation from the U.S. Fish and Wildlife to the County of Sacramento, a 40-acre LAU was used to generate the results for the VWADI presented in the ARP. The 40-acre LAUs allow for more detailed analysis and preserve planning.

2.3 Assigned Intervals Based Upon Vernal Pool Wetted Acres

As described in Section 5.2.3 of the 2010 *Vernal Pool Classifications*, 25 VWADI categories were designated using 5 intervals, designated A–E, based on vernal pool density and 5 intervals,

APPENDIX B-2 (Continued)

designated 1–5, based on vernal pool wet-acres¹ within the LAUs. The VWADI letter category for vernal pool wetland density is presented in Table B2-1. The attributes and assigned VWADI letter category for vernal pool density was not modified in the analysis presented in the ARP even though the LAU was reduced in size from 160 to 40 acres. For example, a 160-acre LAU with more than 100 vernal pools was assigned as “E” in the 2010 *Vernal Pool Classifications*, whereas in the ARP a 40-acre LAU would have to include more than 100 vernal pools to be assigned “E.”

Table B2-1
Assigned Intervals Based Upon Vernal Pool Density

Total Number of Vernal Pools/LAU	VWADI Letter Category
1–10	A
11–25	B
26–50	C
51–100	D
>100	E

The attributes and assigned VWADI number category for vernal pool wetted acres was scaled to the 40-acre LAU in the analysis presented in the ARP. The VWADI number category for the vernal pool wet-acres in the 2010 *Vernal Pool Classifications* and the ARP are presented in Table B2-2 to show the differences between the two analyses. The more stringent requirement for the vernal pool density factor, in combination with the reduction in the size of the LAU, provides a more fine-grained analysis of the VWADI categories across the Plan Area landscape.

Table B2-2
Assigned Intervals Based Upon Vernal Pool Wetted Acres

Total Acres Vernal Pools/LAU		VWADI Number Category
2010 <i>Vernal Pool Classifications</i>	ARP	
0–2	0–0.5	1
2–4	0.5–1	2
4–6	1–1.5	3
6–10	1.5–2.5	4
>10	>2.5	5

¹ The wet-acres or wetted acres is equivalent to the area delineated as a vernal pool in the land cover data.

APPENDIX C

Functional Assessment for the South Sacramento Habitat Conservation Plan and Aquatic Resources Plan

DRAFT

**Functional Assessment for the South Sacramento Habitat
Conservation Plan and Aquatic Resources Program**

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Functional Assessment for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

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Functional Assessment for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

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Functional Assessment for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

1 INTRODUCTION

The purpose of the functional assessment for the South Sacramento Habitat Conservation Plan (SSHCP) and Aquatic Resources Program (ARP) is to provide a landscape-level assessment of the quality and condition of “potentially jurisdictional waters/wetlands areas” (PJWA) in the Plan Area. The analysis will assist in determining which potentially jurisdictional aquatic resource areas have the highest quality based on the criteria described below and the highest potential for restoration and conservation. Additionally, the data will inform a determination as to whether or not the compensatory mitigation strategy designed under the combined Endangered Species Act (ESA) and Clean Water Act (CWA) regulatory framework of the SSHCP and ARP adequately addresses the potential loss of waters of the U.S. In order to reach these conclusions, overall aquatic resource condition was evaluated by aquatic resource type, habitat type, water quality, hydrologic functioning, geomorphic region, and adjacent land use.

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Functional Assessment for the South Sacramento Habitat Conservation Plan and Aquatic Resources Program

2 METHODS

The aquatic resources analyzed in the functional assessment include vernal pools, swales, ephemeral streams, seasonal wetlands, freshwater marsh, mine tailing riparian woodland, mixed riparian scrub, mixed riparian woodland, open water, streams/creeks, and valley oak riparian woodland. Points were assigned to each aquatic resource based on the following factors:

- Area of the aquatic resource;
- Watershed (hydrologic unit code (HUC) 10-digit cataloging units);
- Primary adjacent land cover;
- Secondary adjacent land cover; and
- Aquatic resource type.

Function scores are assigned for each of these factors, per aquatic resource feature, based upon ability to maintain or improve the following functions:

- **Habitat.** Points are added if a given type of aquatic resource has the potential to support covered wildlife and plant species.
- **Water Quality.** Points are added for a resource type with the ability to improve or maintain water quality through such processes as filtration and/or trapping of contaminants such as sediment or toxicants and prevention of erosion.
- **Hydrology.** Points are added for a resource type that can facilitate groundwater recharge and store floodwaters via beneficial flood storage and flood flow modifications.

Functional analysis scoring was conducted for both current conditions within the Plan Area and future conditions, which assumed full implementation of the SSHCP. However, the only factor that changed as a result of SSHCP implementation was the watershed factor.

2.1 Functional Analysis Scoring

2.1.1 Factor 1 – Area of Aquatic Resource

The area of aquatic resource factor is based on the ecological rationale that aquatic resources that are greater in size are generally higher functioning. Therefore, habitat, water quality, and hydrology functional scores will be increased for each aquatic resource that is greater than the median area for its aquatic resource type (see Table 1).

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Table 1

Factor	Effect on Function Scores		
	<i>Habitat</i>	<i>Water Quality</i>	<i>Hydrologic</i>
	<i>Area</i>		
Greater than median area for type	+2	+2	+2
Less than median area for type	0	0	0

2.1.2 Factor 2 – Watershed

The Plan Area has been divided into ten HUC 10-digit cataloguing units, as defined by the Federal Standard for Delineation of Hydrologic Unit Boundaries (USGS and USDA NRCS 2009): the American River, Deer Creek, Laguna Creek, Lower Cosumnes, Lower Dry Creek, Lower Mokelumne River, Morrison Creek, Sherman Lake – Sacramento River, Snodgrass Slough, and Upper Cosumnes. Each of the HUC 10-digit cataloguing units were characterized in terms of land use, soils, hydrology, and geology in the SSHCP ARP Watershed Plan. Based upon this data, the aquatic resources within each HUC 10 cataloging unit were assigned points for habitat, water quality, and hydrology functions, based upon which HUC 10 watershed they occur in, as follows:

- Habitat** – The habitat function scores for Factor 2 were based on Covered Species occurrences (percentages) within each HUC 10 watershed. For current conditions, Covered Species occurrence percentages within the Plan Area range from 2% to 33%. Points for the habitat function scores were assigned within a range of -3 to +3 along a linear scale commensurate with percentage Covered Species occurrences (e.g. a watershed with 0% to 5% occurrence was given a score of -3, indicating the poorest habitat quality; whereas a watershed with 31% to 35% occurrence was given a score of +3, indicating the best habitat quality). For future conditions, Covered Species occurrence percentage distribution among watersheds will be much more bimodal in nature, in which species will either occur within a watershed or not. Therefore, if a watershed is expected to contain Covered Species in the future, it was assigned a score of +3, whereas a watershed that is not expected to contain Covered Species was assigned a score of -3.
- Water Quality** – The water quality function scores for Factor 2 were based on percentage natural land cover within each HUC 10 watershed. Unnatural land cover types considered included both urban (e.g., stormwater runoff typical to commercial, industrial, residential properties) and agriculture (e.g., agricultural stormwater runoff with potential to introduce fertilizer, pesticides, animal waste, irrigation, and/or sediment laden runoff into an aquatic feature). For current conditions, natural land cover percentages within the Plan

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Area range from 9% to 73%; for future conditions, percentages range from 6% to 71%. Points for the water quality function scores were assigned within a range of -3 to +3 along a linear scale commensurate with percentage natural land cover (e.g. a watershed with 5% to 15% natural land cover was given a score of -3, indicating the poorest water quality; whereas a watershed with 66% to 75% natural land cover was given a score of +3, indicating the best water quality).

- **Hydrology** – The hydrology function scores for Factor 2 were based on percentage impervious surface within each HUC 10 watershed. Current condition impervious surface percentages range from 1% to 31%; future condition percentages range from 1% to 77%. Points for the hydrology function scores were assigned within a range of -3 to +3 along an inverse linear scale commensurate with percentage impervious surface (e.g. a watershed with 35% to 31% impervious surface was given a score of -3, indicating the most disturbed hydrology; whereas a watershed with 5% to 0% impervious surface was given a score of +3, indicating the least disturbed hydrology).

American River

Approximately 12,060 acres, or about 18%, of the 53,360-acre American River watershed is located within the Plan Area. This watershed comprises 3.2% of the entire Plan Area and is located in the northern portion of the Plan Area. A little more than half of the watershed contains non-habitat land cover types, which primarily includes high-density development and mine tailings. The remaining undeveloped land consists of valley grassland, mine tailing riparian woodland, mixed riparian woodland, blue oak woodland, and savanna and mixed riparian scrub. Aquatic resources account for only approximately 130 acres, or about 1%, of the American River watershed. Impervious surfaces cover approximately 3,080 acres, or 26%, of the watershed within the Plan Area.

The American River watershed includes documented occurrences for 10 of the 30 Covered Species, including: Boggs Lake hedge-hyssop (*Gratiola heterosepala*), tricolored blackbird (*Agelaius tricolor*), Cooper's hawk (*Accipiter cooperii*), Swainson's hawk (*Buteo swainsoni*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), vernal pool fairy shrimp (*Branchinecta lynchi*), vernal pool tadpole shrimp (*Lepidurus packardii*), white-tailed kite (*Elanus leucurus*), burrowing owl (*Athene cunicularia*), and northern harrier (*Circus cyaneus*). However, about 58% of the American River watershed has been influenced by human activities with over half of the watershed dominated by the aforementioned non-habitat land covers. Subsequently, in combination with making up only 3% of the Plan Area, the portions of the American River watershed within the Plan Area do not support a high overall percentage of the Covered Species occurrences (2%) in the Plan Area.

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Current conditions – Due to the low percentage of Covered Species occurrences, the American River watershed has a score of -3 for its habitat function. It has a moderate percentage of natural land cover, resulting in a water quality score of +1. It has a relatively large amount of impervious surface, resulting in a hydrology function score of -2.

Future conditions – The American River watershed will have less than 1% Covered Species occurrence and thereby has a score of -3 for its habitat function. It will have a mid-level percentage of natural land cover, resulting in a water quality score of 0. It will contain a large amount of impervious surface, resulting in a hydrology function score of -3.

Deer Creek

The Deer Creek watershed bisects the Plan Area, extending from the northeastern edge to halfway into the Plan Area. Of the 82,980 acres of the watershed, 46,810 acres (56%) are within the Plan Area. A large majority (93%) of the watershed contains “habitat” land covers, which includes agriculture. Terrestrial land covers (32,980 acres and 70% of the watershed), consisting primarily of valley grassland (25,450 acres and 54% of the watershed), account for the majority of the watershed. Other terrestrial land covers include blue oak savanna and woodland (14% of the watershed), mixed riparian woodland, mixed riparian scrub, and mine tailing riparian woodland and valley oak riparian (0.02% of the watershed). Approximately 20% (9,940 acres) of the watershed consists of lands used for agricultural purposes and 7% (3,300 acres) fall under the non-habitat land cover type. The remaining 2% of the watershed (1,070 acres) consists of aquatic resources such as streams and creeks, open water, and vernal pools. Impervious surfaces cover approximately 370 acres, or only 1%, of the watershed within the Plan Area.

The Deer Creek watershed includes documented occurrences for 16 of the 30 Covered Species, including: Boggs Lake hedge-hyssop, Sacramento Orcutt grass (*Orcuttia viscida*), Sanford’s arrowhead, burrowing owl, Cooper’s hawk, ferruginous hawk, loggerhead shrike, northern harrier, Swainson’s hawk, tricolored blackbird, valley elderberry longhorn beetle, vernal pool fairy shrimp, vernal pool tadpole shrimp, western pond turtle, western spadefoot, and white-tailed kite. This watershed contains 6% of the known occurrences for these 16 Covered Species, and contains a substantial percentage of occurrences for two of the Covered Species, including 49% of the Sacramento Orcutt grass records and 20% of the ferruginous hawk records. Covered species have been recorded throughout the watershed, with the majority occurring along hydrological features and within aquatic or terrestrial habitat. A cluster of vernal pool species records occur along the border of Deer Creek and Morrison watersheds east of the intersection of Grant Line Road and Keifer Boulevard.

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Current conditions – The Deer Creek watershed has a relatively low percentage of Covered Species occurrence, and therefore had a score of -2 for its habitat function. However, it has a high percentage of natural land cover, resulting in a water quality score of +3. It also has a low percentage of impervious surface, resulting in a hydrology function score of +3.

Future conditions – The Deer Creek watershed will have an increased percentage of Covered Species occurrence in the future, and therefore had a future score of +3 for its habitat function. It will also have a high percentage of natural land cover, resulting in a water quality score of +3. It will have a somewhat high percentage of impervious surface, resulting in a hydrology function score of -1.

Laguna Creek

The Laguna Creek watershed is approximately 98,150 acres, of which 75,350 acres are within the Plan Area, and comprises 20% of the Plan Area. It is located in the southeastern portion of the Plan Area and contains virtually all of the mapped land cover types in the Plan Area. The large majority (91%) of the Laguna Creek watershed is undeveloped. Combined, valley grassland, blue oak savanna, and blue oak woodland account for 61% (approximately 46,310) acres of the land covers in the watershed, and 68% of the “natural” land covers, including agriculture. Agriculture accounts for 24% (approximately 17,730 acres) of the land covers in the Plan Area. The Laguna Creek watershed also supports all of the aquatic cover types except wetland restoration, including approximately 2,820 acres of vernal pool, seasonal wetland, and swale, approximately 420 acres of streams/creeks, and almost 300 acres of open water. Non-habitat land cover types comprise only 9% of the watershed, with low-density development accounting for 61% of the non-habitat land cover types. Impervious surfaces cover approximately 2,010 acres, or only 3%, of the watershed within the Plan Area.

The Laguna Creek watershed includes documented occurrences for 23 of the 30 Covered Species, reflecting both its large size and diversity of land cover types. Covered species documented in the watershed include dwarf downingia, legenere, pincushion navarretia (*Navarretia myersii* ssp. *myersii*), Sacramento Orcutt grass, vernal pool fairy shrimp, Ricksecker’s water scavenger beetle, vernal pool tadpole shrimp, mid-valley fairy shrimp, California tiger salamander, western spadefoot, western pond turtle, giant garter snake, Cooper’s hawk, burrowing owl, loggerhead shrike, northern harrier, ferruginous hawk, greater sandhill crane, Swainson’s hawk, tricolored blackbird, white-tailed kite, western red bat, and Yuma myotis. This watershed has the highest percentage (26%) of known occurrences for Covered Species after the Morrison Creek watershed, including 17% of the vernal pool covered plant occurrences and 40% of the vernal pool invertebrate occurrences.

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Current conditions – The Laguna Creek watershed has a relatively high percentage of Covered Species occurrence, yielding a habitat function score of +2. It also has a high percentage of natural land cover, resulting in a water quality score of +3, and a low percentage of impervious surface, resulting in a hydrology function score of +3.

Future conditions – The Laguna Creek watershed will have a high percentage of Covered Species occurrence in the future, yielding a habitat function score of +3. It will also maintain a high percentage of natural land cover, resulting in a water quality score of +3. Its percentage of impervious surface will increase, however, resulting in a hydrology function score of +1.

Lower Cosumnes

The Lower Cosumnes River watershed is 47,310 acres, entirely located within the south-central portion of the Plan Area. This watershed consists primarily of terrestrial and agricultural land covers, accounting for 81% of the land covers in the watershed. The terrestrial category is dominated by valley grasslands (14,610 acres), which accounts for approximately 31% of the total terrestrial land cover in the watershed. Agricultural areas total 21,220 acres and are the largest land covers in the Lower Cosumnes River watershed. Approximately 7% (3,510 acres) of the watershed is aquatic land covers, including seasonal wetlands, open water, freshwater marsh, vernal pools, wetland restoration, streams and creeks and swales. Approximately 12% (5,710 acres) of the watershed is non-habitat land cover dominated by low-density development (3,990 acres) and high-density development (1,260 acres). Impervious surfaces cover approximately 1,650 acres, or only 3%, of the watershed.

The Lower Cosumnes River watershed includes documented occurrences for 19 of the 30 Covered Species, including dwarf downingia, legenere, Sanford's arrowhead, vernal pool fairy shrimp, mid-valley fairy shrimp, Ricksecker's water scavenger beetle, valley elderberry longhorn beetle, California tiger salamander, giant garter snake, western pond turtle, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, and white-tailed kite. This watershed contains 10% of the Plan Area's known occurrences of Covered Species.

Current conditions – The Lower Cosumnes River watershed has a relatively low percentage of Covered Species occurrence, which gives it a habitat function score of -2. It has a mid-range percentage of natural land cover, resulting in a water quality score of 0. It has a low percentage of impervious surface, yielding a hydrology function score of +3.

Future conditions – The Lower Cosumnes River watershed will have some Covered Species occurrences in the future, and therefore has a future habitat function score of +3. It will continue

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to have a mid-range percentage of natural land cover, resulting in a water quality score of 0. It will have a slightly increased amount of impervious surface compared to current conditions, which yields a hydrology function score of +1.

Lower Dry Creek

The Lower Dry Creek watershed is located along the southern edge of the Plan Area. Approximately 50% of the watershed is located within the Plan Area. The watershed has very little non-agricultural development. Of the 18,570 acres in the watershed, approximately 56% are terrestrial land covers and 38% are agricultural land covers. Valley grasslands dominate the terrestrial land cover in the watershed, comprising 14,610 of the 16,880 acres mapped as terrestrial. The large majority (92%) of agricultural areas are cropland and vineyards. Aquatic and non-habitat land covers each comprise about 3% of the remaining acreage within the watershed. Impervious surfaces cover approximately 140 acres, or only 1% of the watershed within the Plan Area.

The Lower Dry Creek watershed includes documented occurrences for 9 of the 30 Covered Species, including legenere, pincushion navarretia, vernal pool fairy shrimp, vernal pool tadpole shrimp, California tiger salamander, western spadefoot, northern harrier, Swainson's hawk, and tricolored blackbird. Overall, the watershed only contains 2% of the Covered Species occurrences, but it does contain 33% of the pincushion navarretia occurrences (16 of 49) and 19% of the California tiger salamander occurrences (6 of 29).

Current conditions – Due to the low percentage of Covered Species occurrence, Lower Dry Creek has a habitat function score of -3. However, it has a relatively high percentage of natural land cover, which gives it a water quality score of +2. And its low percentage of impervious surface gives it a hydrology function score of +3.

Future conditions – The Lower Dry Creek watershed will have less than 1% Covered Species occurrence in the future, which gives it a habitat function score of -3. It will still have a relatively high percentage of natural land cover, resulting in the same water quality score of +2. It will have slightly more impervious surface, resulting in a hydrology function score of +2.

Lower Mokelumne River

Although the Lower Mokelumne River watershed is more than 66,200 acres in size, only 3% of the watershed is located in the far southwest corner of the southern Plan Area and it accounts for only 0.5% of the Plan Area. The small portion of this watershed located within the Plan Area is primarily made up of agricultural land covers, specifically croplands. The remaining acreage

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includes mixed riparian scrub and woodland, aquatic land covers, and some residential areas. Impervious surfaces cover approximately 30 acres, or 1% of the watershed within the Plan Area.

The Lower Mokelumne River watershed only contains three documented occurrences of one Covered Species: Sanford's arrowhead. This species is located on the boundary of the Plan Area within the Mokelumne River. Similar to the Lower Dry Creek watershed, the lack of occurrences of Covered Species within this watershed may be attributed to large amounts of land that have been converted for agricultural purposes. In addition, only a very small portion of the watershed is actually located within the Plan Area. Due to its small size within the Plan Area, the Lower Mokelumne watershed includes less than 1% of the modeled habitat for Covered Species.

Current conditions – Lower Mokelumne River has a habitat function score of -3 due to its low percentage of species occurrence. It has a relatively low percentage of natural land cover, resulting in a water quality function score of -2. However, its low percentage of impervious surface yields a hydrologic function score of +3.

Future conditions – Lower Mokelumne River watershed will still have a habitat function score of -3 due to its low percentage of species occurrence. It will have an even lower percentage of natural land cover, resulting in a water quality function score of -3. However, it will maintain its low percentage of impervious surface and will still have a hydrologic function score of +3.

Morrison Creek

The Morrison Creek watershed is located within the northern half of the Plan Area. Of the 82,790 acres that comprise this watershed, 85%, or 70,320 acres, are located within the Plan Area, almost entirely inside the Urban Development Area (UDA). This is the second largest watershed in the Plan Area, second only to the Laguna Creek watershed. Because it is located in the urbanizing portion of Sacramento County, approximately 45% of the watershed has already been developed and contains non-habitat land covers, primarily high-density development. Agriculture accounts for about 7% of the watershed. Terrestrial (44%) and aquatic (4%) land covers account for the remaining land covers in the Morrison Creek watershed. Valley grassland accounts for about 96% of the terrestrial land cover. This watershed also supports all of the aquatic cover types, including approximately 890 acres of vernal pools, 430 acres of swale, and 230 acres of seasonal wetlands, which are embedded in the valley grasslands. Laguna Creek (north) is a significant east-west landscape feature that plays a prominent role in conservation. Impervious surfaces cover approximately 18,260 acres, or 26%, of the watershed. Along with the American River (26% impervious surfaces) and Sherman Lake-Sacramento River (31% impervious surfaces) watersheds, the Morrison Creek watershed has one of the three highest percentages of impervious surfaces in

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the Plan Area. Reflecting both its large size and more urbanized character, it also has by far the highest amount of impervious surface acreage in the Plan Area, with Snodgrass Slough having the second highest amount at approximately 7,670 acres.

The Morrison Creek watershed includes documented occurrences for 26 of the 30 Covered Species despite substantial urbanization. Covered species documented in the watershed include Ahart's dwarf rush, Boggs Lake hedge-hyssop, dwarf downingia, legenere, pincushion navarretia, Sacramento Orcutt grass, slender Orcutt grass, Sanford's arrowhead, vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, Ricksecker's water scavenger beetle, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, western spadefoot, giant garter snake, western pond turtle, American badger, and western red bat. This watershed has the highest percentage (33%) of known occurrences for Covered Species in the Plan Area, including 50% of both the covered vernal pool plants and vernal pool invertebrate occurrences. Due to the large area of vernal pools (almost 900 acres and second only to the Laguna Creek watershed), swale, and seasonal wetlands, vernal pool flora and fauna are the most important biological resources in the watershed.

Current conditions – Because Morrison Creek contains the highest percentage of Covered Species occurrences, it has a habitat function score of +3. It has a moderate percentage of natural land cover, yielding a water quality function score of +1. It has a relatively large amount of impervious surface, giving it a hydrologic function score of -2.

Future conditions – Morrison Creek will have a much lower percentage of Covered Species occurrences in the future, however, it will still maintain a small percentage and therefore has a future habitat function score of +3. It will continue to have a moderate percentage of natural land cover, yielding a water quality function score of +1. It will have an increased percentage of impervious surface, giving it a hydrologic function score of -3.

Sherman Lake–Sacramento River

The Sherman Lake-Sacramento River watershed is located in the extreme western portion of the Plan Area, with approximately 29% located within the Plan Area. The watershed intersects the Plan Area in four separate locations that together comprise about 5% of the Plan Area, including a large area along the northern portion of the Plan Area, a small area in the northwest corner of the Plan Area, and two areas along the western portion of the Plan Area. The Sherman Lake-Sacramento River watershed in the Plan Area is dominated by human activities. Together, non-habitat and agricultural land cover types account for 91% of the land covers in the watershed. Of these two land cover types, high-density development and cropland contain the largest acreages

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at 5,360 and 5,440 acres, respectively, accounting for 58% of the total land covers in the watershed within the Plan Area. The Sherman Lake-Sacramento River watershed contains all of the aquatic land cover types mapped within the Plan Area, but in small amounts ranging from 2 to 40 acres and totaling only 110 acres. Terrestrial land covers, primarily valley grassland, comprise the remaining acreage, but only totaling 1,450 acres, or 8% of the land cover in the watershed within the Plan Area. Impervious surfaces cover approximately 5,690 acres, or 31%, of the watershed, which is the highest percentage of the watersheds in the Plan Area.

The Sherman Lake-Sacramento River watershed includes documented occurrences for 10 of the 30 Covered Species, including Sanford's arrowhead, vernal pool fairy shrimp, burrowing owl, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, and western red bat. Overall, the watershed accounts for only 1% of the Covered Species occurrences in the Plan Area. The large majority (91%) of the Sherman Lake-Sacramento River watershed is developed or agriculture, which is reflected in the relatively small number of Covered Species with occurrences in the watershed compared to several of the other watersheds.

Current conditions – Sherman Lake-Sacramento River has the lowest scores (-3) for all three functions, as a result of its low percentage of Covered Species occurrence, its low percentage of natural land cover, and its high percentage of impervious surface.

Future conditions – Sherman Lake-Sacramento River watershed will continue to have low scores (-3) for all three functions in the future.

Snodgrass Slough

Snodgrass Slough is the third largest watershed in the Plan Area behind the Laguna Creek and Morrison Creek watersheds and is entirely contained within the western portion of the Plan Area. About 54% of the watershed is agriculture, of which, about 66% is croplands; croplands cover about 35% of the entire watershed. Non-habitat land cover types, dominated by high-density development, account for 22% of the watershed. Terrestrial habitat, dominated by valley grassland (78%), mixed riparian scrub and woodland and woodland restoration, covers about 16% of the watershed. The Snodgrass Slough watershed accounts for the highest acreage of aquatic land cover within the Plan Area. Approximately 4,220 acres of the watershed supports all of the aquatic cover types mapped within the Plan Area, and represents 24% of the aquatic habitat in the Plan Area. Impervious surfaces cover approximately 7,670 acres, or 15%, of the watershed. While this watershed has a relatively smaller proportion of impervious surfaces compared to American River and Morrison Creek at 26% and Sherman Lake-Sacramento River at 31%, it has a substantially higher level of impervious surfaces than the remaining watersheds, which range from 1% to 3%.

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The Snodgrass Slough watershed includes documented occurrences for 19 of the 30 Covered Species, including dwarf downingia, legenere, Sanford's arrowhead, vernal pool fairy shrimp, vernal pool tadpole shrimp, mid-valley fairy shrimp, giant garter snake, western pond turtle, burrowing owl, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, greater sandhill crane, Swainson's hawk, tricolored blackbird, white-tailed kite, American badger, and Yuma myotis. This watershed contains 13% of known occurrences for Covered Species in the Plan Area, third only to the Morrison Creek (35%) and Laguna Creek (26%) watersheds.

Current conditions – Snodgrass Slough has a moderate to low percentage of Covered Species occurrences, resulting in a habitat function score of -1. It has a relatively low percentage of natural land cover, which gives it a water quality score of -2. It has a mid-range percentage of impervious surface, yielding a hydrologic function score of 0.

Future conditions – The Snodgrass Slough watershed will have less than 1% of Covered Species occurrences in the future, resulting in a habitat function score of -3. It will have a slightly low percentage of natural land cover, which gives it a water quality score of -1. It will have a relatively low percentage of impervious surface, yielding a hydrologic function score of +2.

Upper Cosumnes

The Upper Cosumnes River watershed is located in the east-central portion of the Plan Area, which encompasses about 51% (32,000 acres) of the watershed. The majority of the watershed in the Plan Area (21,220 acres, or 66%), consists of terrestrial habitat dominated by valley grassland. Agricultural areas comprise about 11% and aquatic areas comprise about 5% of the watershed in the Plan Area. Non-habitat land cover, primarily low-density development, covers the remaining 18% of the watershed. Impervious surfaces cover approximately 340 acres, or only 1%, of the watershed.

The Upper Cosumnes River watershed includes documented occurrences for 14 of the 30 Covered Species, including legenere; Sanford's arrowhead; vernal pool fairy shrimp, vernal pool tadpole shrimp, valley elderberry longhorn beetle, western spadefoot, Cooper's hawk, ferruginous hawk, loggerhead shrike, northern harrier, Swainson's hawk, tricolored blackbird, white-tailed kite, and western red bat. This watershed contains 9% of documented occurrences of Covered Species within the Plan Area. Most notably, the watershed contains 153 of the 156 known occurrences (98%) of valley elderberry longhorn beetle, with the largest concentration of occurrences along the Cosumnes River just south of Rancho Murieta.

Current conditions – Upper Cosumnes has a relatively low percentage of Covered Species occurrences, which gives it a habitat function score of -2. However, it has a high percentage of

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natural land cover, and a low percentage of impervious surface, yielding respective water quality function and hydrologic function scores of +3.

Future conditions – The Upper Cosumnes watershed will have a greatly increased percentage of Covered Species occurrences in the future, which gives it a habitat function score of +3. It will continue to have a high percentage of natural land cover, yielding a water quality score of +3. It will have a slightly increased percentage of impervious surface, which will result in a hydrologic function score of +1.

HUC 10	Effect on Function Scores		
	<i>Habitat</i>	<i>Water Quality</i>	<i>Hydrologic</i>
American River	-3	+1	-2
Deer Creek	-2	+3	+3
Laguna Creek	+2	+3	+3
Lower Cosumnes	-2	0	+3
Lower Dry Creek	-3	+2	+3
Lower Mokelumne River	-3	-2	+3
Morrison Creek	+3	+1	-2
Sherman Lake-Sac River	-3	-3	-3
Snodgrass Slough	-1	-2	0
Upper Cosumnes	-2	+3	+3

Table 3

HUC 10	Effect on Function Scores		
	<i>Habitat</i>	<i>Water Quality</i>	<i>Hydrologic</i>
American River	-3	0	-3
Deer Creek	+3	+3	-1
Laguna Creek	+3	+3	+1
Lower Cosumnes	+3	0	+1
Lower Dry Creek	-3	+2	+2
Lower Mokelumne River	-3	-3	+3
Morrison Creek	+3	+1	-3
Sherman Lake-Sac River	-3	-3	-3
Snodgrass Slough	-3	-1	+2
Upper Cosumnes	+3	+3	+1

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2.1.3 Factors 3 and 4 – Primary and Secondary Adjacent Land Cover

For the purposes of this analysis, adjacent land cover types within the Plan Area were assigned to one of four classes:

- **Class IA:** Vernal pool valley grassland.
- **Class I:** Ephemeral streams, freshwater marsh, open water, seasonal wetland, streams/creeks, swale, vernal pool, wetland restoration, aqueducts, blue oak savanna, blue oak woodland, mine tailing riparian woodland, mixed riparian scrub, mixed riparian woodland, valley grassland, valley oak riparian woodland, and woodland restoration.
- **Class II:** Cropland, irrigated pasture-grassland, orchards, vineyards, eucalyptus woodland, and recreation/landscaped.
- **Class III:** Disturbed, high-density development, low-density development, major roads, mine tailings.

Class IA only includes vernal pool valley grassland land covers, and these are considered to be indicative of the highest quality, contiguous vernal pool complexes within the Plan Area. Therefore, aquatic resources adjacent to Class IA land covers have increased habitat, water quality, and hydrologic scores, with a particular emphasis on habitat. Class I land covers generally enhance or have positive impacts on the function of aquatic resources. Habitat, water quality, and hydrologic function scores were therefore increased for aquatic resources with Class I primary adjacent land covers. (see Table 4).

Class II land covers are characterized by open space with a moderate level of disturbance. The land covers may include crop species or exotic landscape species, but the open space provides some habitat value. Habitat function scores were neutral (0) for aquatic resources with Class II primary adjacent land covers. The open space associated with Class II land covers facilitate infiltration and reduce the flashiness of the local hydrograph; however, Class II land covers are generally associated with altered hydrological regimes (e.g. straightened canals and ditches); therefore, hydrologic function scores were also considered neutral (0) with Class II primary adjacent land covers. Since most land uses in Class II are non-point sources of natural and human-made pollutants such as excess sediment, nutrients, fertilizer, herbicide, and insecticide laden run-off from agricultural land scores decreased for aquatic resources with Class II primary adjacent land cover.

Class III land covers are urban and developed. This land cover provides little habitat value and generates urban runoff, creating sources of pollutants such as lawn fertilizers, chemicals, oil and grease. Habitat and water quality function scores were therefore greatly reduced (-3) for aquatic

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resources with Class III primary land cover types. Urban areas are also generally characterized by fairly intensive hydrologic modification. Therefore, hydrologic scores were also reduced (-2) for aquatic resources with Class III primary adjacent land cover.

Table 4

Factor	Effect on Function Scores		
	<i>Habitat</i>	<i>Water Quality</i>	<i>Hydrologic</i>
<i>Primary Adjacent Land Cover</i>			
Class IA	+2	+1	+1
Class I	+1	+1	+1
Class II	0	-1	0
Class III	-3	-3	-2

When more than one land cover type is adjacent to a PJWA, the adjacent land cover with the greatest linear feet of shared border with the PJWA being evaluated is the primary adjacent land cover. The land cover with the second greatest linear feet of shared border with the PJWA being evaluated is the secondary adjacent land cover. Secondary land covers are assumed to have the same type of effect on jurisdictional wetlands and waters as primary land cover types, but to a lesser extent and were scored (weighted) closer to neutral for all land cover types (see Table 5).

Table 5

Factor	Effect on Function Scores		
	<i>Habitat</i>	<i>Water Quality</i>	<i>Hydrologic</i>
<i>Secondary Adjacent Land Cover</i>			
Class IA	+1	0	0
Class I	0	0	0
Class II	0	-1	0
Class III	-2	-2	-1

If there was only a primary land cover and no secondary land cover, the corresponding secondary land cover score was used for Factor 4 (e.g. if the PJWA was only surrounded by Class I land covers, the Factor 3 scores would be +1 for habitat, +1 for water quality, and +1 for hydrologic; and the Factor 4 scores would be 0 for habitat, 0 for water quality, and 0 for hydrologic). Both Factor 3 and Factor 4 scores were used in all cases, to avoid higher scores for features solely based on the fact that more than one adjacent land cover exists.

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2.1.4 Factor 5 – The Aquatic Resource Type

The aquatic resource type factor is based on the rationale that certain aquatic resources generally have more importance in terms of habitat, water quality, and hydrologic function than other types. Therefore, based on a landscape level assessment of the aquatic resources within the Plan Area, functional scores were increased for aquatic resources that have recognizable potential to support covered wildlife and plant species or assists in benefitting the continued existence of any threatened or endangered species; importance to improve or maintain water quality; and facilitate groundwater recharge and/or store floodwaters (see Table 6).

Table 6

Land Cover Type	Effect on Function Scores		
	<i>Habitat</i>	<i>Water Quality</i>	<i>Hydrologic</i>
Ephemeral Streams	0	0	0
Freshwater Marsh	+2	+1	+1
Streams/Creeks	+1	+2	+2
Mixed Riparian Scrub	+1	0	0
Mixed Riparian Woodland	+1	0	0
Mine Tailing Riparian Woodland	-1	-1	-1
Open Water	0	-1	0
Swale	+1	0	0
Seasonal Wetlands	+1	+1	+1
Vernal Pool	+2	0	0

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3 RESULTS

3.1 Very Low, Low, Moderate, and High-Condition Ranking

The function scores for each aquatic resource were ranked very low, low, moderate, or high based upon the range of scores possible resulting from the sum of all factors (range of -28 to +24). Cutoffs for each condition ranking were determined by assessing natural breaks in the data and distributing the scores roughly evenly in the four different condition bins. The condition breakdowns are as follows: aquatic resources scored between -28 and -14 are considered of “very low” condition, those scored between -13 and -1 are considered “low” condition, those scored between 0 and 12 are considered “moderate” condition, and those scored between 13 and 24 are considered “high” condition. The final total ranking is intended to provide a planning level overview of which mapped aquatic features within the Plan Area provide the highest functions and services and support analysis of trends in the location of higher or lower quality features.

3.2 Summary of Functional Assessment Results

The results of the functional assessment analysis and quality ranking for each aquatic resource mapped in the Plan Area is provided in Appendix A. Within the Plan Area under current conditions, there are a total of 24,255 acres of aquatic resources. 8,280 acres (34.1%) are ranked as high quality, 12,218 acres (50.4%) are ranked as moderate quality, 3,651 acres (15.1%) are ranked as low quality, and 107 acres (0.4%) are ranked as very low quality (Table 7).

Table 7

Wetland or Non-Wetland Waters	Land Cover Type (Common name)	High	Moderate	Low	Very Low	Total
		Acres				
Wetland Waters	Vernal Pools	3067.47	1312.96	157.02	0	4537.45
	Freshwater Marsh	988.01	1697.21	268.85	0	2954.07
	Mine Tailing Riparian Woodland	67.59	363.78	183.39	26.31	641.07
	Mixed Riparian Scrub	112.04	820.23	297.70	44.72	1274.69
	Mixed Riparian Woodland	520.87	3710.31	1554.85	18.75	5804.78
	Seasonal Wetland	1395.77	1019.33	184.65	0	2599.75
	Swales	944.33	302.17	4.98	0	1251.48
Non-Wetland Waters	Open Water	298.33	1206.30	821.06	15.94	2341.63
	Streams/Creeks (Intermittent and Perennial)	840.91	1758.42	177.03	1.03	2777.39
	Streams/Creeks VPIH (Ephemeral)	44.30	27.38	1.51	0	73.19
Total		8279.62	12218.11	3651.03	106.74	24255.50

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Within the Plan Area under impacted conditions, there are a total of 22,644 acres of aquatic resources. 8,308 acres (36.7%) are ranked as high quality, 10,953 acres (48.4%) are ranked as moderate quality, 3,354 acres (14.8%) are ranked as low quality, and 28 acres (0.1%) are ranked as very low quality (Table 8).

Table 8
Summary of Functional Assessment Results under Impacted Conditions

Wetland or Non-Wetland Waters	Land Cover Type (Common name)	Cowardin Class	Remaining Aquatic Resources				Total
			High	Moderate	Low	Very Low	
			Acres				
Wetland Waters	Freshwater Marsh	PEM1	1267.52	1378.039	181.55	0	2827.11
	Mine Tailing Riparian Woodland	R2/R3	130.97	240.96	50.93	0	422.86
	Mixed Riparian Scrub	R2/R3	218.25	665.29	324.23	5.42	1213.18
	Mixed Riparian Woodland	R2/R3	877.72	3332.73	1403.50	6.73	5620.68
	Seasonal Wetland	PEM2	1162.51	1107.77	231.78	0	2502.05
	Swale	R2/R3	575.38	415.57	26.36	0	1017.25
	Vernal Pools	PEM2	2988.20	1078.65	72.26	0	4139.10
Non-Wetland Waters	Open Water	POW	413.55	855.84	903.64	15.47	2188.50
	Perennial or Intermittent Streams/Creeks	R3UB	674.29	1832.19	154.70	0	2661.19
	Streams/Creeks (VPIH) ephemeral	R4SB	0	46.12	5.48	0	51.60
Total			8308.38	10953.10	3354.43	27.62	22643.52

Within the Plan Area under future conditions, there are a total of 24,257 acres of aquatic resources. 9,671 acres (39.9%) are ranked as high quality, 11,204 acres (46.2%) are ranked as moderate quality, 3,354 acres (13.8%) are ranked as low quality, and 28 acres (0.1%) are ranked as very low quality (Table 9).

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Table 9
Summary of Functional Assessment Results under Future Conditions

Wetland or Non- Wetland Waters	Land Cover Type (Common name)	Cowardin Class	Future Condition of Resources				Total
			High	Moderate	Low	Very Low	
			Acres				
Wetland Waters	Freshwater Marsh	PEM1	1425.32	1427.58	181.55	0	3034.46
	Mine Tailing Riparian Woodland	R2/R3	130.97	240.96	50.93	0	422.86
	Mixed Riparian Scrub	R2/R3	257.12	688.08	324.23	5.42	1274.85
	Mixed Riparian Woodland	R2/R3	1178.62	3434.15	1403.50	6.73	6023.0
	Seasonal Wetland	PEM2	1318.72	1132.62	231.78	0	2683.12
	Swale	R2/R3	839.22	419.08	26.36	0	1284.67
	Vernal Pools	PEM2	3362.52	1093.38	72.26	0	4528.16
Non- Wetland Waters	Open Water	POW	413.55	856.32	903.64	15.47	2188.98
	Perennial or Intermittent Streams/Creeks	R3UB	742.03	1866.12	154.70	0	2762.85
	Streams/Creeks (VPIH) ephemeral	R4SB	2.63	46.12	5.48	0	54.23
Total			9670.72	11204.40	3354.43	27.62	24257.17

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APPENDIX D

Re-establishment and Establishment Guidelines

APPENDIX D

Re-establishment and Establishment Guidelines

1 INTRODUCTION

The United States Army Corps of Engineers (USACE) and the US Environmental Protection Agency (EPA) define restoration as, “the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/ historic functions to a former or degraded aquatic resource” (USACE and EPA 2008). Restoration includes both rehabilitation, which repairs natural/historic functions to a degraded aquatic resource, and re-establishment, which returns natural/historic functions to a former aquatic resource. Establishment (i.e., creation) is defined as, “the manipulation of the physical, chemical, or biological characteristics present to develop an aquatic resource that did not previously exist at an upland site.” Re-establishing is always preferable to establishment because the likelihood of success is far greater where some aquatic resource characteristics are already present or were historically present. Additionally, because the establishment of wetland and other waters on upland and/or deepwater sites will result in a net decrease in upland and/or deepwater habitat, this should only occur when there are no existing or available sites with re-establishment opportunities. Even highly degraded and disturbed re-establishment sites are preferable to establishment sites. Nevertheless, it is expected that a portion of mitigation acreage under the South Sacramento Habitat Conservation Plan (SSHCP) will occur as wetland and other waters establishment due to a lack of available restoration sites outside the Urban Development Area (UDA).

This appendix explains the SSHCP protocols for establishment and restoration of wetlands and other water ecosystems. These protocols are based on the USACE’s Mitigation Guidelines for the Clean Water Act (CWA) 404 Program and the United States Environmental Protection Agency’s (EPA) *Principles for Ecological Restoration of Aquatic Resources* (EPA 2000). They are meant to provide applicants with a basic outline for planning, designing, implementing, and managing restoration or establishment projects. In so doing, the protocols are meant to ensure that wetland projects will be viable in perpetuity, and will adequately compensate for impacted habitat. This section will also provide standards that are specific to each of the 10 aquatic resources land cover types, including restoration and establishment methods, monitoring requirements, criteria against which success will be measured, and remedial steps for projects that do not meet the basic success criteria. It is recognized that ecosystem restoration and establishment is an evolving science, and that this document represents current understandings and expectations in the field. Therefore, the application of these protocols will allow adjustments in an adaptive manner to reflect the best available science of wetland and stream establishment and re-establishment, monitoring, and performance standards that can improve the long-term viability of restoration and establishment projects.

APPENDIX D (Continued)

The following methodology describes the process by which determinations were made regarding the potential for establishment and re-establishment acreage amounts to occur within the Plan Area.

Assumptions

Irrigated pasture and croplands are considered the only habitats where removal of the current land use and re-establishment of topography may result in re-established wetlands. Irrigated pasture is considered particularly suitable for re-establishment of wetlands because the hardpan is likely intact. Croplands, depending on the crop, may also retain the hardpan. Both land uses occur where wetlands may have historically occurred.

Orchards and vineyards are not suitable for wetland restoration because the lands have been deep-ripped to support the agricultural uses.

Valley grasslands may be suitable for establishment of wetlands, but only outside of 250 feet of an existing wetland feature so as not to create any indirect effects to the wetland per U.S. Fish and Wildlife Service (USFWS) protocol.

Only land in the Plan Area is considered for re-establishment or establishment.

It is assumed that parcels 20 acres in size or less will be too expensive to acquire and too small to support successful re-establishment or establishment.

It is assumed that existing preserves will not be suitable for re-establishment or establishment as this may risk damaging protected resources and easements may prohibit re-establishment or establishment.

Based on California Department of Fish and Wildlife recommendations, it is assumed that between 15% and 30% of land that is assumed to be suitable habitat will be available for acquisition.

Up to 8% of a site can be re-established or established with wetlands. This is based on the density of wetlands found in Valley Grassland cover type throughout the Plan Area. Wetlands include vernal pools, swales, seasonal wetlands, freshwater marsh, streams and open water. Wetland density within the Plan Area was derived from the acreage of wetlands within the Valley Grassland cover type as this is the only upland cover type that is reflective of historic natural conditions. All other upland cover types have been heavily modified.

Methodology

Identify all Cropland, Irrigated Pasture, and Valley Grassland cover types in the SSHCP Plan Area. This forms the “base map.”

APPENDIX D (Continued)

Using the parcel layer, remove all parcels from the base map that are less than 20 acres in size.

Using the existing preserve layer, remove all parcels from the base map that are already protected.

Using a buffer file, remove all lands from the base map that are within 250 feet of a vernal pool, swale, and stream/creek (VPIH) land cover type.

Calculate range of how many Cropland, Irrigated Pasture, and Valley Grassland acres are available for potential re-establishment or establishment, assuming 15% to 30% of the base map can be acquired.

Calculate range of how many wetland acres can be re-established or established based on 8% density.

Conclusions

The base map sums to 210,509 acres.

After removing lots smaller than 20 acres in size and already preserved lands, the map sums to approximately 135,455 acres.

After removing areas within 250 feet of existing VPIH land covers, the map sums to approximately 85,690 acres.

It is estimated that further investigation into the historical agricultural practices on some of the potential re-establishment or establishment sites will reveal past deep-ripping. Sites that have been deep-ripped will not have an intact perched aquifer, which is necessary to support most wetland cover types. There are some questions as to whether or not the perched aquifer in soils that have been deep-ripped can be repaired. Orchards and vineyards are not considered suitable candidates for re-establishment or establishment because deep-ripping has typically occurred where they were established. It is also understood that acquiring potential re-establishment or establishment sites is dependent on a willing buyer and willing seller agreement. Therefore, it is not probable that all identified potential wetland re-establishment or establishment sites can be acquired for re-establishment or establishment. It is estimated that between 15% and 30% of potential re-establishment or establishment sites will be successfully negotiated for acquisition and will be capable of supporting re-establishment or establishment efforts. Therefore, it is assumed that between 12,854 and 25,707 acres may be available for wetland re-establishment or establishment.

Wetland re-establishment and establishment guidelines set forth in this study limit the percent of land that can be re-established and established to 8% of the site. The remaining 92% is required as upland

APPENDIX D (Continued)

habitat, which supports the hydrology of the wetland. Therefore, it is estimated that between 1,028 and 2,057 acres of wetlands can be re-established or established within the Plan Area.

The SSHCP impacts analysis forecasts that approximately 1,200 acres of wetlands will be impacted. Because we assume that the Plan Area can provide between 1,028 and 2,057 acres of wetland re-establishment and establishment, the re-establishment/establishment ratio under the SSHCP is set at 1:1.

2 GUIDELINES

The restoration and establishment process has several stages: site selection, site evaluation, project design, project implementation, project monitoring, and project management. General protocols for each of these stages are as follows:

2.1 Site Selection

The National Resource Council (NRC) stipulates that “site selection for wetland conservation and mitigation should be conducted on a watershed scale in order to maintain wetland diversity, connectivity, and appropriate proportions of upland and wetland systems needed to enhance the long-term stability of the wetland and riparian systems” (NRC 2001). Protected upstream and upland areas provide a safeguard against the negative edge effects of future development. Therefore, restoration and establishment sites that are contiguous to existing preserves or lands protected by conservation easements will have priority over wetland restoration or establishment sites outside of a comprehensive preserve system. All restoration and establishment sites must be under permanent conservation easement or have preserve status.

Consideration will be given to a site’s position within the watershed, its function within the watershed, and the potential impacts of restoration or establishment on existing proximate wetland and other aquatic resource habitats within the same watershed. Restoration or establishment sites that can benefit the watershed in which they are situated will have priority over those with little to no impact; sites with no potential impact on the watershed in which they are situated will have priority over those with potential negative impacts. Sites with potential negative impacts to the watershed or nearby habitat will be avoided.

Wetlands and other waters that have retained functional hydrodynamics or degraded and former wetlands whose hydrodynamics can be re-established through passive restoration tend to be more fiscally and environmentally sustainable than those where functional hydrodynamics must be engineered or created. Active hydrodynamic restoration methods, like grading and excavation can severely damage the substrate and encourage the spread of invasive plant species. “Hard” engineering solutions, such as irrigation and pumping systems, are costly and cannot readily adapt to seasonal and annual fluctuations in rainfall and water level. Hence, restoration and establishment sites that do not require active intervention to remediate wetland or other waters hydrodynamics will have priority over other sites. No restoration or establishment projects that use irrigation as a primary or long-term water source are permitted.

Soil type and permeability are also important considerations, as they dictate a site’s ability to retain water and support vegetation. Highly permeable soils are not likely to retain enough water to function as a wetland or other water ecosystem, except where water tables or water inflow

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rates are high. Factors such as soils pH, nutrient content, climate, parent material, relief, organisms, and the overriding influence hydrologic regime, will influence whether wetland-appropriate vegetation struggles or thrives. Therefore, restoration and establishment sites with soil types known to support wetland hydrology and vegetation will have priority over other sites.

Additionally, restoration and establishment site selection will consider the potential effects of habitat restoration on nearby County airport operations. Pursuant to Title 33 of the Code of Federal Regulations (CFR) Section 332.3, compensatory mitigation projects should not be located where they will increase risks to aviation by attracting wildlife to areas where aircraft–wildlife strikes may occur (e.g., near airports). Thus, those sites that are less likely to increase wildlife hazard attractants within a County airport's approach and departure airspace will be given priority over other sites.

Lastly, because a central goal of mitigation is to offset unavoidable adverse impacts to wetlands, streams, and other aquatic resources to maintain a diverse assortment of wetland types, functions, landscape settings, and geomorphic settings, sites that have unique or rare topographical, geomorphic, vegetative, biotic, or functional characteristics will have priority over other sites.

In summary, the Implementing Entity will prioritize restoration and establishment sites that:

- Are contiguous to existing preserves or lands under conservation easements;
- Can withstand re-establishment or establishment projects without adverse impacts to the watershed or habitat in which they are situated;
- Do not require active intervention to remediate wetland or other waters' hydrodynamics;
- Have appropriate soil types, composition, and permeability;
- Do not attract wildlife within the approach and departure airspace of County airports, and
- Have unique or rare characteristics.

Once a restoration or establishment site is selected, a reference site will be identified. Reference sites should be in-kind and as proximate to the restoration or restoration site as possible. The site being mitigated for can be used as the reference site if it is reasonably proximate and similar to the restoration or establishment site, and if it has not been destroyed prior to the start of the restoration or establishment project. Reference sites should not be chosen randomly, but rather so that collectively they represent the diversity of species and plant communities that exist on the sites that are going to be destroyed.

2.2 Site Evaluation

Once the restoration or establishment site and the reference site are selected, an interdisciplinary team of experts will survey the site. This team will include the Implementing Entity and at least one Monitoring Biologist (MB). The MB will be a professional botanist, biologist, or restoration ecologist familiar with California flora and fauna, and experienced with wetland or other waters re-establishment or establishment projects; alternatively, the MB can be a firm specializing in the re-establishment or establishment of wetlands and other waters. This person or firm will be contracted to perform the baseline evaluation (in addition to the monitoring responsibilities detailed in Section 2.5).

The baseline evaluation will actually consist of two surveys: one in wet season (January to February) and one in the flowering period (March through May). Each survey should note the following, using either metrics on or descriptions of:

- Topography and slope;
- Water quality (turbidity, nutrient levels, presence of toxins, etc.);
- Subsurface water flow rate, direction, depth, and duration;
- Surface water flow rate, direction, depth, and duration;
- Soil/substrate type, permeability, moisture levels, and erosion;
- Dominant vegetation type, location, density, and elevation;
- Presence and location of invasive species;
- Presence and location of listed species;
- Aquatic function (if any);
- Historical and current uses of the site; and
- Historical and current uses of neighboring land that may affect the project outcome.

Surveys of plant and animal species specific to particular wetland or other water types may need to occur within a more specific time frame or multiple times over the course of the survey period for the results to be accurate and reliable. These particular survey requirements will be detailed within the restoration and establishment guidelines of each wetland and other water type.

The reference site should be surveyed at the same time and using the same methods and metrics as the restoration or establishment site.

2.3 Project Design

Project design depends upon the desired outcome of each project. The overarching goal for all mitigation projects under the SSHCP is an ecosystem strategy approach to re-establish or establish sustainable and functioning ecosystems that match the characteristics and functions of the ecosystems they replace within a system of conservation areas and reserves so that species dispersal mechanisms remain functional. However, depending on project-specific constraints and opportunities, this may be too broad or constraining. Therefore, the Implementing Entity and MB will use the baseline evaluation findings to set project-specific goals and to design the project with the aim of meeting those goals. As part of the project design, the team will also generate an implementation plan that describes how the design will be implemented. Lastly, the team will generate a monitoring and management plan, which will include project-specific outcomes, criteria against which progress toward meeting those objectives can be measured, and the monitoring methods that will be used to measure those criteria.

In general, passive restoration design is preferable to active restoration, as it is less invasive and the result is self-sustaining. Passive restoration involves removing the source of degradation (e.g., cattle grazing, culverts, etc.) and allowing natural process to gradually return the site to a functioning wetland or other water ecosystem. However, passive restoration design will not meet the goals of every restoration project, especially on severely degraded sites, and passive designs cannot be used for establishment projects. Therefore, it is expected that some projects will utilize active restoration and establishment project designs.

The USACE South Pacific Division's *Final 2015 Regional Compensatory Mitigation and Monitoring Guidelines* (USACE 2015) recommend the following considerations for mitigation planning: A mitigation plan for wetland compensatory mitigation projects should consider the NRC's operational guidelines for restoring ecologically self-sustaining wetlands (NRC 2001). This succinct document provides some useful guidelines on factors to consider in planning wetland compensatory mitigation. In addition, examination of existing compensatory mitigation sites has provided information that can be used to ensure the success of proposed compensatory mitigation sites. In general, compensatory mitigation sites should be designed with the following in mind.

General Design Recommendations for Compensatory Mitigation

- Ensure an adequate buffer subject to minimal or no human disturbance is established and protected adjacent to any aquatic resources in the compensatory mitigation site.
- Integrate macro- and micro-topographic features to create a diversity of hydrologic and geomorphic conditions, plant communities, and animal habitat.

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- Design the compensatory mitigation project to mimic a local reference site of similar class and landscape position that provides the desired habitat features and functionality.
- Incorporate mitigation plantings of species native to the local area.
- Avoid or minimize impacts to special-status species and other biological resources.

Design Recommendations for Wetland Compensatory Mitigation

- Select compensatory mitigation sites with natural, self-sustaining sources of hydrology (surface water, groundwater, and precipitation). The use of engineered structures such as pumps, water control structures, or diversions is strongly discouraged. Securing water rights and/or understanding the risks of existing or future water diversions are critical elements.

Design Recommendations for Stream Compensatory Mitigation

- Ensure the main channel through the compensatory mitigation site is free to migrate laterally over its active and terrace floodplain.
- Ensure channel geometry (plan, profile, and cross-section) of the compensatory mitigation site is appropriate for the watershed location and physical/hydrological condition.
- Use local, native materials as fill material to the extent practicable.
- Use bioengineering techniques to the extent practicable.
- Establish/restore and protect riparian areas next to the stream channel.

Additionally, project designs must address the three fundamental components of wetland ecosystems: hydrology, substrate, and vegetation. According to the NRC's Committee on the Characterization of Wetlands (NRC 1995):

The states of the three factors that characterize wetlands are... recurrent, sustained saturation (the hydrological criterion), physical and chemical conditions in the substrate that reflect recurrent, sustained saturation (the substrate criterion), and the presence of organisms that are specifically adapted to recurrent and sustained saturation of the substrate (the biologic criterion).

2.3.1 Hydrology

The project design should describe how topography and hydrology of the site will be altered (if at all) to re-establish or establish the appropriate hydrodynamics and hydroperiod for the wetland or other water ecosystem. The design should also explain what aquatic function is expected to result from this change.

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This component of the project design should utilize natural hydrologic patterns whenever possible, and avoid depending on hard engineering to achieve the desired hydrology. Soft engineering is always preferable to hard engineering, as it is more natural and self-sustaining, requires minimal maintenance, and is more cost-effective. As explained in Section 2.1, grading, excavation, pumping, and irrigation are undesirable and should be avoided. Irrigation is never acceptable as a primary or long-term water source.

2.3.2 Substrate

The project design should describe how (if at all) the soil or substrate will be amended or translocated to re-establish or establish the appropriate level of saturation and nutrient/organic matter content for the wetland or other water ecosystem. The project design should utilize existing soil and substrate whenever appropriate for the wetland or other water type being re-established or established. To avoid the spread of invasive species, soil and/or substrate translocated from off site should be sourced from sites free of invasive species.

2.3.3 Vegetation

The project design should describe how (if at all) the site will be vegetated or revegetated. Substrate, plants, and seeds collected from the site can be used to revegetate and repopulate the site after hydrology is re-established or established. When no native seed bank exists, site-suitable plant species should be procured from as local a source as possible. Off-site plant, seed, and substrate collection should come from local sites free of invasive species. Commercial seeds for native plants can be substituted if no local seed banks are available. Project designs, especially active designs, should use variation to allow for adaptive management. When designs include excavation or grading, they should provide appropriately heterogeneous topography. When designs include revegetation, they should create varying plant elevations and emergence levels. Such variations enable flexibility in case of extreme weather events and other unpredictable factors that can affect the project.

In summary, the Implementing Entity will design restoration and establishment projects that:

- Are based on foreseeable constraints and information derived from the baseline evaluation;
- Strive to meet project-specific goals, outcomes, and success criteria;
- Specify monitoring frequency and management protocols;
- Are passive, whenever possible;
- Address the water, substrate, and biota that compose the wetland or other water type;

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- Utilize existing hydrological patterns, topography, soil, substrate, native vegetation, and/or local seed banks, whenever possible; and
- Create variation to allow for experimentation and adaptive management.

2.4 Implementation

The implementation plan must provide a timeline for the project implementation, and must describe all avoidance and minimization measures that the Implementing Entity will take during implementation of the project. These measures are described in detail in Chapter 7 Conservation Strategy of the SSHCP.

2.4.1 Timing

Implementation will occur either before or after the breeding and aestivation seasons of species present at the restoration or establishment site. The Implementing Entity will also time the implementation so that revegetation occurs during the appropriate growing season. If the planned implementation season arrives with unexpectedly poor conditions (e.g., drought, flood, etc.) the Implementing Entity will postpone project implementation until better conditions emerge, up to one calendar year or 18 months.

2.4.2 Avoidance and Minimization

Prior to entering the restoration or establishment site all boots, tools, truck tires, truck beds, and any other equipment should be washed and disinfected to limit the spread of invasive species and disease. If invasive species are already present at the re-establishment or establishment site prior to implementation, and the project design involves eradicating such species, the Implementing Entity will use mowing, hand weeding, and other natural methods to do so. Herbicides and pesticides will be avoided.

When the project design involves excavation or grading, the Implementing Entity will salvage appropriate native soils, substrate, and plant materials from the re-establishment or establishment site, whenever possible. Seeds with viable embryos should be collected by hand, with scissors, or with clippers, and stored under cool and dry conditions. Substrate should be harvested using a hammer or backhoe to loosen blocks that are at least 6 inches deep, and stored on greenhouse flats wrapped in damp fabric.

All tools should be removed from the site after implementation, except those needed for monitoring purposes.

2.5 Monitoring

A monitoring schedule will be developed as part of the project design process (see Section 2.3). Monitoring should occur with the highest frequency during and immediately after implementation. These surveys should include the same metrics and descriptions as the baseline evaluation.

Long-term monitoring should include an annual Biological Inspection, and more detailed quantitative and qualitative surveys every 5 years. The Biological Inspection will consist of one or more walk-through surveys that note:

- Hydrology;
- Vegetation composition;
- Presence and location of invasive species;
- Wildlife presence; and
- Condition of habitat features, including changes and/or pending needs.

Surveys should include photo documentation where useful. Summary reports of monitoring results should be submitted to the Implementing Agency by the end of each monitoring year.

The Monitoring Biologist (MB) is responsible for all near- and long-term monitoring of the re-establishment or establishment site. Ideally, the same MB will perform both the baseline evaluation (detailed in Section 2.2) and project monitoring for the duration of the monitoring period. However, a change of the MB can be made in consultation with the Implementing Agency, and with the Implementing Entity's approval at the time of change. The exiting MB will give a tour and introduction of the site to the entering MB.

Duties of the MB include, but are not limited to:

- Monitoring site function, hydrology, and erosion control;
- Monitoring water quality;
- An annual Biological Inspection of the site; collecting data and preparing reports based on this Inspection;
- Monitoring presence, vigor, location, and density of vegetation and biota;
- Evaluating the accumulation of thatch and recommending removal, when necessary;
- Evaluating the presence of newly introduced, non-native, or exotic plant species, and recommending removal, when necessary;

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- Recommending allowable activities on the site, e.g. educational activities, tours, grazing, etc.; and
- Recommending remedial or corrective actions, to be implemented by the Implementing Entity.

2.6 Management

The Implementing Entity is responsible for the near- and long-term management and maintenance of the restoration or establishment site. Long-term management is necessary to ensure that the restoration or establishment project is viable as a wetland or other water habitat in perpetuity. The Implementing Entity's management duties will include, but not be limited to:

- Maintaining fencing and signage;
- Coordinating trash removal;
- Removing thatch and dead vegetative matter to reduce fire hazard;
- Removing and/or managing exotic and invasive plant species, when necessary;
- Coordinating grazing schedules, when applicable;
- Coordinating the annual Biological Inspection by the MB;
- Reviewing monitoring data and performing general inspections; and
- Implementing remedial or corrective action when necessary.

The Implementing Entity will coordinate with the MB to determine when and where remedial or corrective action is necessary and feasible.

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3 LITERATURE CITED

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